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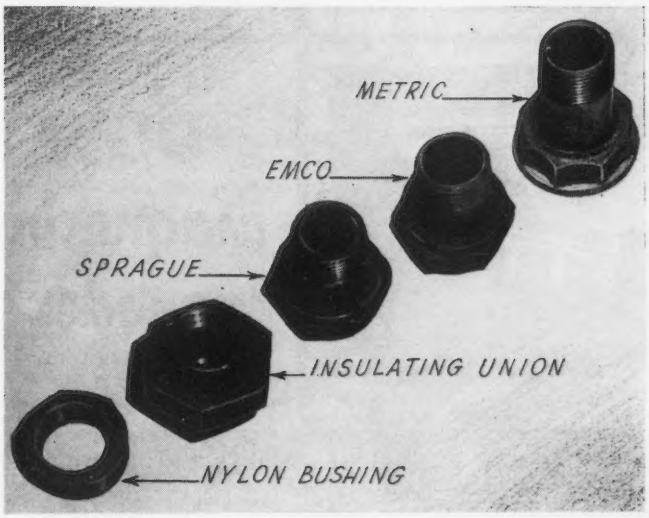

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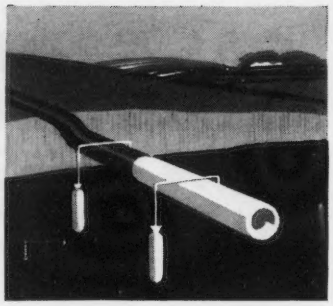
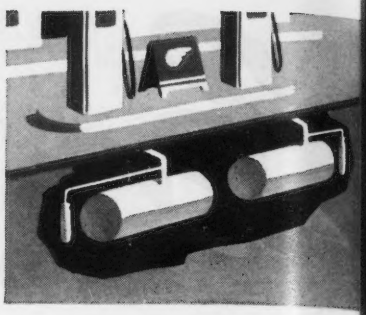
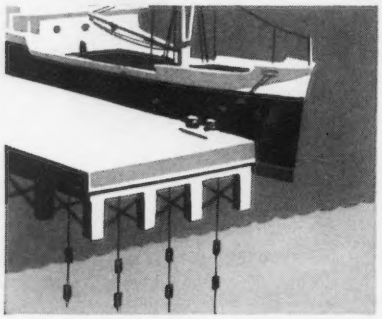
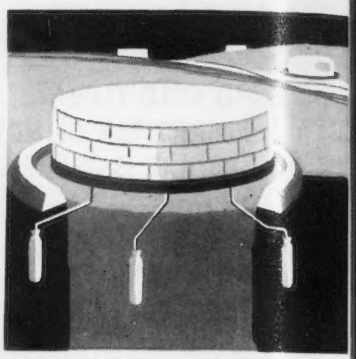
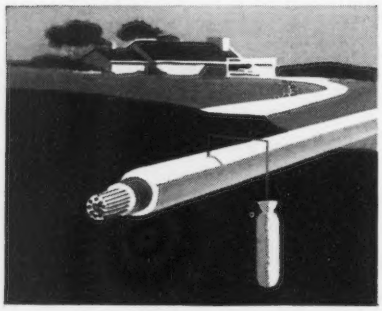


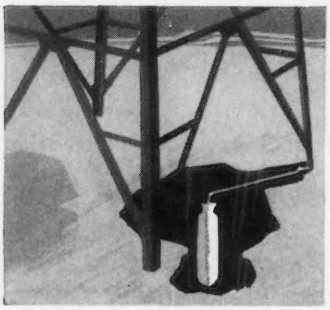


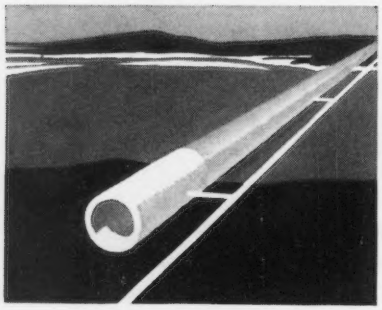


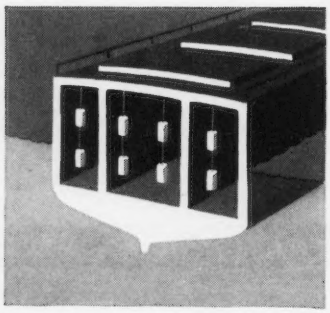
DOW magnesium anodes











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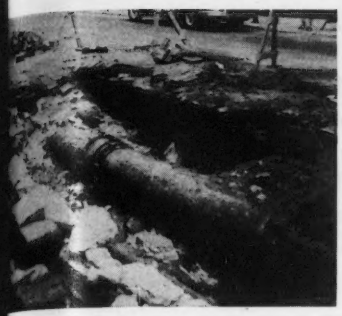

THIS MONTH'S COVER—Repaired section of 30-inch, 80-year-old water main on Broadway at Canal Street, Manhattan, New York, is shown here. This main broke during the night of September 30, 1952 flooding the BMT subway along Broadway at this point and express tracks to Brooklyn, 60 feet underground. It is estimated 500,000 persons were late to work because subway cars had to be rerouted around the flooded tunnels. Water ripped up 30 yards of street over the main.

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- **Authors of technical papers on corrosion are invited to submit titles and abstracts of papers to appropriate officials of the Technical Program for the 1953 Chicago Conference of the National Association of Corrosion Engineers, to be held March 16-20.**
- **Information on symposia titles and the names of symposia chairmen named to date will be found in the News Section of the October issue of Corrosion.**
- **The Association also welcomes at any time constructive discussions of its technical material and technical papers on corrosion for publication in Corrosion.**
- **Interested authors may secure on request a copy of the "NACE Guide for the Preparation and Presentation of Papers" which describes the Association's customs and needs more fully.**

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(Continued from Page vi)

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Other Products: Field Jointers;
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Write, wire or telephone for literature,
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*Available from Houston Warehouse Stock.

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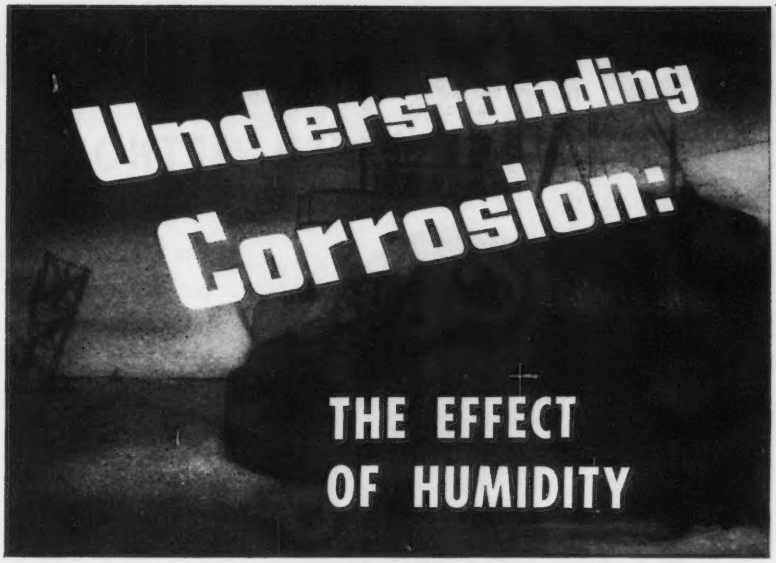


Relative humidity — the degree to which air is saturated with moisture — influences corrosion in one direction where metal is exposed to atmosphere and in another where it is immersed in a solution surface-exposed to the same atmosphere.

It is humidity, in combination with temperature, that determines whether moisture can exist on a metal surface. Because moisture is essential to atmospheric corrosion, humidity, at normal temperatures, becomes the factor that determines whether corrosion will occur and to what extent. Its effect, negligible below 30%, increases until a critical point is reached at about 65%. When air so moisture-laden carries even minute quantities of such gases as sulphur dioxide, corrosive action is greatly intensified. It is this condition that renders difficult the protection of steel stacks, breechings and economizers in service below the dew point.

For metal immersed in a corrosive solution, the reverse is true. More rather than less humidity in the air above is the preferable situation because of the way in which humidity influences the rate of oxygen solution. The rapid evaporation that occurs in dry atmosphere leaves a cool, dense surface layer of liquid that carries dissolved oxygen through the solution as fresh, unsaturated liquid replaces it for a repetition of the process. As the pace at which oxygen is brought in contact with the metal is thus stepped up, corrosion increases proportionately.

Protection of metal exposed to atmosphere or immersed in corrosive solutions, particularly under difficult or unusual service conditions, has long been the function of Dampney equipment-engineered coatings. Our experience in the handling of corrosion problems peculiar to industrial power and processing operations is not only extensive but specific . . . applicable, we feel sure, to your individual needs. Let us tell you more about Dampney coatings and what they offer . . . in terms of *your* requirements.

MAINTENANCE FOR METAL

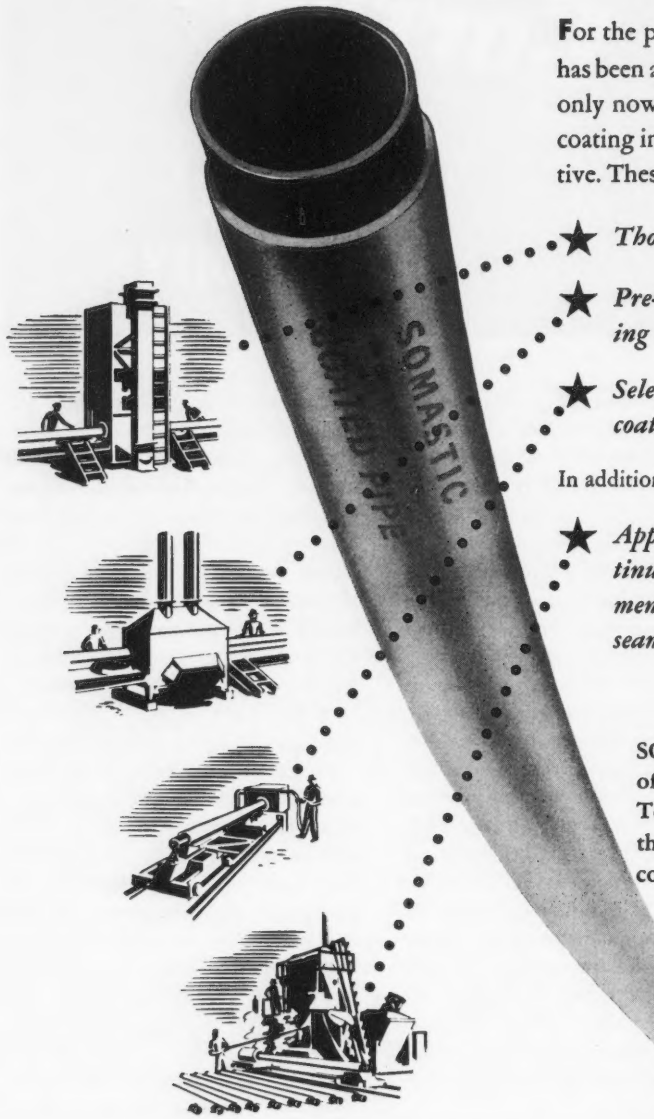
THE DAMPNEY COMPANY

155-1

HYDE PARK, BOSTON 36, MASSACHUSETTS

SOMASTIC* PERMANENCE

includes TIME TESTED METHODS of Application



For the past 20 years SOMASTIC PIPE COATING has been applied to pipe by standard practices which only now are being adopted generally by the pipe coating industry. Time has proved them most effective. These methods are—

★ *Thorough cleaning of metal by grit-blasting.*

★ *Pre-heating, followed by hot priming, assuring a firm, lasting bond of coating to steel.*

★ *Selection of materials and manufacture of coating to rigid specifications.*

In addition, SOMASTIC leads in this essential feature—

★ *Application of coating to primed pipe in a continuous process by special* SOMASTIC *equipment to form a dense, compact, uniform and seamless protective coating of great durability.*

The general swing to methods pioneered by SOMASTIC Pipe Coating is another acknowledgment of a fact first shown by the API-Bureau Of Standards Ten Year Pipe Coating Tests . . . and since proved at thousands of corrosive locations . . . for *permanence* coat with SOMASTIC.

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*Reg. U. S. Patent Office
PIPE COATING

Unequaled for PERMANENT PROTECTION

SOMASTIC IS The Best PIPE COATING

MANUFACTURED BY

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BARTLESVILLE, OKLAHOMA
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In the 37 States East of the Rocky Mountains

BECHTEL CORPORATION
SAN FRANCISCO and WILMINGTON
CALIFORNIA
In the 11 Western States and in Foreign Countries

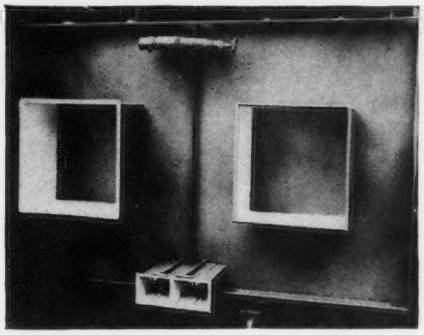
Boiler feed water tank shown encrusted with rust and mineral deposits before metallizing.

Feed water tank being metallized after preparation by grit blasting.

metallizing cuts tank maintenance ...extends life

pure zinc coatings used on both fresh and salt water types

This 20-year old tank, used by a St. Louis brewery for boiler feed water supply, had become so badly scaled that it seemed ready for the scrap heap. Instead it was metallized with a .008" coating of pure aluminum, after being cleaned by grit blasting. Job was done between 6 P.M. one Friday night and 6 P.M. the following Sunday, during a plant shut-down. This tank is now good for another 15 years, at least. Work done by the St. Louis Metallizing Co.



Tuna clipper bait tank protected with Metco System #107 Normally necessary to scale and repaint every six months. Metallized tanks in service over four years without further maintenance.

Salt water bait tanks

The tank type shown here is used on west coast tuna clippers for salt water storage of live bait. Tank interiors are painted white to prevent the bait from killing themselves against the bulkheads. With paint alone, it is necessary to scale and repaint these tanks every six months. Tanks metallized in accordance with Metco System 107, which provides the desired white surface over .006" metallized zinc, have already been in service over 4 years without any further maintenance. (Photo courtesy Clark Metallizing Co.)

The Metco* Systems. **These Systems are a series of 18 basic engineering specifications developed over 19 years of experience with pure zinc and aluminum coatings on many different types of structures and equipment. The Metco Systems provide the answer to standardization of surface preparation, metal coating thicknesses and organic after-coatings for various service conditions and appearance requirements.**

Here are 10 Metco System contractors

The following organizations are set up to provide positive corrosion protection at lower annual cost in accordance with Metco System specifications. For further information, or copy of descriptive bulletin, contact the one nearest you.

* *Reg. U. S. Pat. Off.—Property of Metallizing Engineering Co., Inc.*

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Only a job-engineered system which provides for every factor affecting your installation can assure complete protection from corrosion. **HARCO** has pioneered in the field of cathodic protection and is equipped to engineer and install systems which will entirely eliminate the menace of corrosion.

For maximum pipe life, minimum maintenance, and protection from the hazards caused by corrosion damage . . . **call upon HARCO!**

Write today for catalog or call MOntrose 2-2080

THE *Harco* CORPORATION

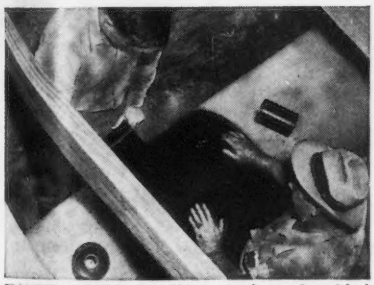
Cathodic Protection Division

16991 BROADWAY • CLEVELAND, OHIO

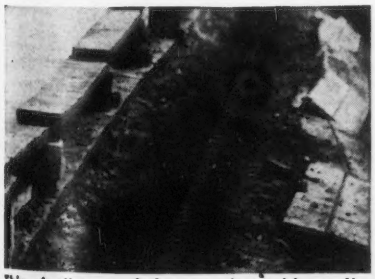
NEW from Johns-Manville

TRANTEX *polyvinyl* TAPE

. . . a cold applied wrap that protects underground and overhead oil and gas lines from corrosion



TRANTEX® TAPE simplifies coating of welded joints of mill-wrapped pipe—shields the pipe against corroding agents.



This pipeline needed protection without disrupting service. TRANTEX TAPE did the job. *No heated kettles required . . . labor costs kept low.*

FOR more than fifty years Johns-Manville has been manufacturing pipeline protection material. This experience, plus the knowledge gained in the research laboratory and in the field about the effects of corrosion, have gone into the making of "Trantex"—a new plastic tape for extending the service life of oil and gas lines.

Trantex needs no special equipment in its application. It is easily applied by hand or hand-operated devices. A pressure-sensitive adhesive forms a tight bond with the pipe—shields it against the general corrosive conditions that cause most pipeline failures. Trantex has proved remarkably resistant to the effects of soil chemicals, acids, alkalies, alcohols, oil and grease, sunlight and aging.

Check the basic properties of Trantex in the table below—each one is extremely important in the control of corrosion.

For more detailed information about Trantex *polyvinyl* Tape, write to Johns-Manville, Box 60, New York 16, N. Y.; in Canada, 199 Bay Street, Toronto 1, Ont.

	*V-10	**V-20
Dielectric Strength	10,000 V	20,000 V
Insulation Resistance	100,000 megohms	100,000 megohms
Operating Temperature	200 F	200 F
Adhesion	30 oz per inch	20 oz per inch
Tensile Strength	30 lbs per inch	56 lbs per inch
Elongation at Break	250%	300%

"Trantex" is a black polyvinyl tape. It is available in two thicknesses—*V-10 is a 10 mil tape for general conditions, and **V-20 is a 20 mil thickness for use where a more rugged coating is specified.

JM JOHNS-MANVILLE PRODUCTS

Johns-Manville TRANTEX® *polyvinyl* TAPE

PROTECTS PIPELINES AGAINST CORROSION

THE NATIONAL ASSOCIATION OF CORROSION ENGINEERS

is a non-profit, scientific and research association of individuals and companies concerned with corrosion or interested in it, whose objects are:

(a) To promote the prevention of corrosion, thereby curtailing economic waste and conserving natural resources.

(b) To provide forums and media through which experiences with corrosion and its prevention may be reported, discussed and published for the common good.

(c) To encourage special study and research to determine the fundamental causes of corrosion, and to develop new or improved techniques for its prevention.

(d) To correlate study and research on corrosion problems among technical associations to reduce duplication and increase efficiency.

(e) To promote standardization of terminology, techniques, equipment and design in corrosion control.

(f) To contribute to industrial and public safety by promoting the prevention of corrosion as a cause of accidents.

(g) To foster cooperation between individual operators of metallic plant and structures in the joint solution of common corrosion problems.

(h) To invite a wide diversity of membership, thereby insuring reciprocal benefits between industries and governmental groups as well as between individuals and corporations.

It is an incorporated association without capital stock, chartered under the laws of Texas. Its affairs are governed by a Board of Directors, elected by the general membership. Officers and elected directors are nominated by a nominating committee in accordance with the articles of organization. Election is by the membership.

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Corrosion

OFFICIAL MONTHLY PUBLICATION

National Association of Corrosion Engineers

An Association of Individuals and Organizations Concerned with Control of Corrosion

1061 M & M Building Houston 2, Texas

Vol. 8 November, 1952 No. 11

Technical Practices Committee 3— *Anodes for Use With Impressed Currents*

By A. W. PEABODY, *Vice-Chairman**

AS THE USE of cathodic protection became of increasing importance as a major weapon in the fight against corrosion on the nation's pipelines, it soon became apparent to operating engineers that there was a need for additional information concerning anodes used in the construction of ground connections for impressed current from an external source. This was particularly emphasized by experience with early ground connections, normally made of scrap steel or cast iron, which in many cases were unpredictable in performance, were subject to rapid consumption and required excessive maintenance. Recognizing this need for knowledge concerning new anode materials or better means of using the materials then available, Technical Practices Committee 3, known as TP-3, was formed in 1947 for the specific purpose of studying anodes for impressed current and making the committee findings available to users of cathodic protection. Since its inception, this committee has been under the able guidance of Donald H. Bond, Chairman, who is presently on extended sick leave.

Committee TP-3 has engaged in an extensive field test program involving periodic controlled tests on a number of different types of anode installations. The various test installations were so arranged that relative performance of the several anode types could be readily analyzed for varying soil resistivities and installation conditions throughout an extensive geographical area. The program for each installation, involving a group of the various anodes under test, extended over a four year period and included performance tests on each anode monthly (or as frequently as practical) as well as yearly removal and inspection of one of each type of anode installed. The data so obtained has permitted the formation of reliable conclusions concerning performance of the several installation methods tested. Such a program was only possible with the willing cooperation of management of operating companies participating in the tests. Even though appreciable capital investment was required on which relatively little direct return could be expected, the participating companies realized that the tests could result in the development of suitable anode materials and installation methods which would permit great future savings in their ever-increasing cathodic protection installation programs.

The efforts of this committee have already been of invaluable assistance to operating companies even though a final report on the above-described test program has not yet been published. Dissemination of information through well attended committee meetings (66 members and guests at the Galveston meeting) and through an interim report (NACE Publication 50-1) has resulted in changed anode installation practices by many operators to conform to findings of the committee test program.

Future plans for activities by this committee include the study and field testing, if warranted, of new types of anodes for impressed current. This may include entirely new materials or new methods of utilizing materials now in common use. The committee welcomes suggestions concerning new materials or methods and will consider their merits from the standpoint of meeting desirable characteristics of low material consumption with time in various environments, ready availability, low purchase cost, strength to withstand normal handling during field installation work and freedom from excessive maintenance.

Another activity now under consideration would involve the study of techniques of designing ground anode installations to meet required values of resistance to earth. Design methods now in use vary widely as well as do closely associated soil testing techniques. By correlating all available information on methods presently used, a study by the committee should result in the evolution of a useful design guide covering the most effective design procedures and treating the effects of the several variables encountered in the construction of ground connections. Such a guide, coupled with the use of the best available construction materials found suitable by committee tests, should promote standardization and serve as a valuable aid in the construction of economical cathodic protection installations.

Membership of Technical Practices Committee 3 presently is eleven. The committee welcomes additional members interested in the activities of this group since, in an active program, a larger membership will permit suitable delegation of effort and will make available a greater cross section of opinion when analyzing the results of any phase of the program.

The membership of Committee TP-3 is given below.

TP-3 ANODES FOR USE WITH IMPRESSED CURRENTS

CHAIRMAN: Donald H. Bond, The Texas Pipeline Company, Box 2332, Houston, Texas.

VICE-CHAIRMAN: A. W. Peabody, Ebasco Services, Inc., 2 Rector Street, New York 6, N. Y.

MEMBERS:

W. A. Broome, Arkansas-Louisiana Gas Co., Slattery Building, Shreveport, Louisiana.
K. S. Hagius, Colorado Interstate Gas Company, Box 1087, Colorado Springs, Colorado.
David Hendrickson, East Bay Municipal Utility District, 512 Sixteenth Street, Oakland, California.
Derk Holsteyn, Shell Oil Company, Box 2527, Houston, Texas.
H. E. James, Mississippi Valley Gas Company, Jackson, Mississippi.
J. P. Oliver, Union Carbide & Carbon Corp., National Carbon Division, Box 6087, Cleveland, Ohio.
O. C. Roddey, Interstate Natural Gas Company, Box 1482, Monroe, Louisiana.
L. N. Spinks, Cathodic Protection Service, 4601 Stanford St., Houston, Texas.
F. A. Young, Susquehanna Pipe Line Company, 1608 Walnut St., Philadelphia, Pa.

* Ebasco Services, Inc., 2 Rector St., New York 6, N. Y.

The Work of the Protective Coatings (Corrosion) Sub-Committee*

By F. FANCUTT and J. C. HUDSON

Abstract

The authors survey the result of investigations of protective coatings for structural iron and steel extending over twenty years. In the field of painting, the research has thrown into relief the vital importance of correct surface preparation and the value of using inhibitive priming paints. Studies of the formulation of anti-corrosive paints, both for land and marine structures are in progress in collaboration with the paint industry. In the field of metallic coatings, basic data have been obtained for the performance of aluminum, cadmium, lead, tin and zinc coatings under various conditions of atmospheric exposure. The durability of zinc coatings has been shown to be roughly proportional to their thickness and but little affected by the process of application. Sprayed aluminum has proved an effective coating but lead coatings have given good results only in an industrial atmosphere, where they become covered with a protective sulfate film.

Introduction

THE IMPORTANCE of knowledge of the correct application of protective coatings for steel and other metals has never been greater than at present when, for various reasons, output lags sadly behind existing and potential demands. As was emphasized during the recent discussions at the Lake Success Conference on the Conservation of Material Resources[1] one potent step towards equating supply to demand is to reduce the large quantities of metals needed purely for replacement purposes. Corrosion plays a major part in dstroying iron or steel structures and the more general adoption of efficient protective measures would undoubtedly lead to considerable economies.

These facts were recognized long ago by the Corrosion Committee of the Iron & Steel Institute and the British Iron and Steel Federation, which is now a committee of the British Iron and Steel Research Association. In its earlier researches, begun in 1930, the committee paid attention not only to the conduct of tests on bare ferrous metals but also to the protection of structural iron and steel by means of paint. It soon became clear that a panacea for rusting could not be found solely in changes in the composition of the metal itself. In 1935 the committee decided that, in view of the importance of protective coatings in preserving iron and steel structures from rusting and the increasing amount of attention that they were finding it necessary to devote to this subject, a Protective Coatings (Corrosion) Sub-Committee should be appointed to deal more particularly with research in this field.

As time elapsed, the sub-committee's researches has extended and its orientation changed. In particular it has become desirable to pay attention to the formulation of protective paints and it is gratifying to record that this important work is proceeding with the full collaboration of the paint industry. The extent of their collaboration will be gathered from the present membership, given below, of two joint technical panels of the sub-committee, which are responsible for the detailed conduct of tests relating to land and marine structures, respectively.

J. C. HUDSON, born in 1900, was educated at Brighton College and the Royal College of Science, London, where he gained his Associateship. After engaging in post-graduate research in physical chemistry, he investigated atmospheric corrosion for the British Non-Ferrous Metals Research Association, which led to his being awarded the D.Sc. (London). Since 1929 he has been Investigator to the Corrosion Committee, originally of the Iron and Steel Institute but now under the aegis of the British Iron and Steel Research Association.

F. FANCUTT, F.R.I.C., A.M.I.Mech.E., was employed by the London North Western Railway at Wolverton in 1912 and, after war service, rejoined the Railway and was posted to the Crewe Chemical Laboratory, later being transferred to Wolverton to take charge of a small laboratory dealing with paints and other materials.

On the formation of the London Midland & Scottish Railway, he was transferred to Derby to set up a new paint testing organization, which was later embodied in the Research Department of British Railways.

In October, 1950, he was appointed Superintendent, Chemistry Div. of the Research Department, British Railways, controlling 11 Area Chemical Laboratories in various parts of Great Britain with Headquarters in London.

He has served on the Corrosion Committee and Protective Coatings Sub-Committee of the British Iron & Steel Research Association, and has been Chairman of Joint Technical Panels dealing with the production of steel under atmospheric and marine exposures. He also has served on numerous national bodies connected with corrosion and its prevention over the past 20 years.

★ Read before Liverpool Section of the Oil and Color Chemists' Association, London, February 8, 1952. Authors are indebted to the association for permission to reproduce it here. Presented by A. J. Liebman, Dravo Corp., Pittsburgh, at the Eighth Annual Conference, National Association of Corrosion Engineers, Galveston, Texas, March 10-14, 1952, under the title "Values of Surface Preparation and/or Pretreatment for Use in Conjunction with Various Outstanding Paint Systems in Industrial and Marine Atmospheres."

Joint Technical Panel/J/Pl.
PAINTS FOR STRUCTURAL STEELWORK
(Constituted in 1945)

F. Fancutt, Chairman, The Railway Executive (British Railways).
E. J. Bond,[1] Goodlass, Wall and Co., Ltd.
W. A. Edwards,[3] Drynamels Ltd.
C. A. F. Hastilow, O.B.E., Docker Brothers.
L. R. Hickson,[2] Messrs. Hadfields (merton) Ltd.
J. C. Hudson, British Iron and Steel Research Association.
W. P. Jenkins,[1] British Paints Ltd.
C. D. Lawrence, Admiralty Chemical Department, H. M. Dockyard, Portsmouth.
R. St. J. Preston, Chemical Research Laboratory, D.S.I.R., Teddington, Middlesex.
W. J. Smith,[2] Lewis Berger (Gt. Britain) Ltd.
J. F. Stanners, British Iron and Steel Research Association.
E. E. White, Secretary, British Iron and Steel Research Association.

1. Representing the National Federation of Associated Paint, Color and Varnish Manufacturers of the United Kingdom.
2. Representing the Society of British Paint Manufacturers Ltd.
3. Representing the Association of Manufacturers of Bituminous Protective Products, Ltd.

Joint Technical Panel N/P2.
ANTI-CORROSIVE COMPOSITIONS
(Constituted in 1946)

F. Wormwell, Chairman, Chemical Research Laboratory, D.S.I.R., Teddington, Middlesex.
G. P. Acock, British Iron and Steel Research Association.
T. A. Banfield,[2] The British Anti-Fouling Composition & Paint Co., Ltd.
H. E. Harrison,[2] Websters, Ltd.
J. C. Hudson, British Iron and Steel Research Association.
L. Kenworthy,[1] Admiralty Central Metallurgical Laboratory, Emsworth.
C. D. Lawrence,[1] Admiralty Chemical Department, H.M. Dockyard, Portsmouth.
R. Robinson,[2] International Paints, Ltd.
C. Gordon Smith,[3] Alfred Holt and Co.
R. H. Truelove,[2] The Red Hand Compositions Co.
E. E. White, Secretary, British Iron and Steel Research Association.

1. Representing the Admiralty Corrosion Committee.
2. Representing the Association of Ships' Compositions Manufacturers.
3. Representing the British Shipbuilding Research Association.

It should be added that until 1949 the investigation of protective coatings for steel immersed in seawater was in the care of the Marine Corrosion Sub-Committee. When this sub-committee was dissolved in that year this branch of the work was taken over by the Protective Coatings (Corrosion) Sub-Committee, to which Joint Technical Panel N/P2 became responsible.

It will be clear from the above that the historical development of the researches of the Protective Coatings (Corrosion) Sub-Committee falls naturally into three phases:

a) work carried out by the Corrosion Committee before the formation of the Protective Coatings (Corrosion) Sub-Committee in 1935;
b) work of the Protective Coatings (Corrosion) Sub-Committee prior to the formation of the Joint Technical Panels in 1945 and 1946; and
c) work of the Joint Technical Panels J/P1 and N/P2, since 1945 and 1946, respectively.

This division and the major items of research are shown diagrammatically in Figure 1. The researches can be divided into two main groups:

1. Protection by means of paint;
2. Protection by metallic coatings.

Further research has been done on the protection afforded by miscellaneous coatings such as cement, asbestos and vitreous enamel.

1. Protection by Means of Paint

1.1. Early Work of the Corrosion Committee

From 1930 onwards several series of tests on painted iron and steel specimens were begun by the Corrosion Committee.[2] The main objects were two-fold:

1. To ascertain the effect of different methods of preparation for painting on the life of a given paint film;
2. To ascertain whether, other conditions being the same, the nature of the basis iron or steel had any influence on the performance of the protective paint.

Several different wrought irons and steels were included in these tests as the basis material, but in the main, the painting schemes used were limited to two; namely, Scheme A—two coats of red lead priming paint followed by two coats of red oxide finishing paint, and Scheme B—two coats of red oxide paint. Both paints were bound with a linseed oil medium.

Exposure of these painted specimens was made in a dozen or so varied localities, both at home and abroad and some of the tests were continued for 15 years or so. A complete account of the results has not yet been published but the main conclusions became evident after a few years' exposure and may be illustrated by the results given in Table I, which shows the average life to failure in an industrial atmosphere at Sheffield of the standard painting schemes as applied to eight different structural irons and steels. The results demonstrate clearly that the method of surface preparation adopted for painting is the most important single factor determining the life of a painting scheme. The best results were observed on specimens having clean unrusted surfaces

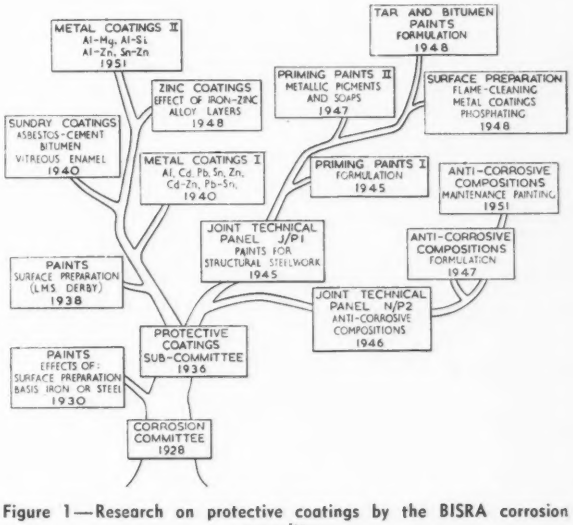

Figure 1—Research on protective coatings by the BISRA corrosion committee.

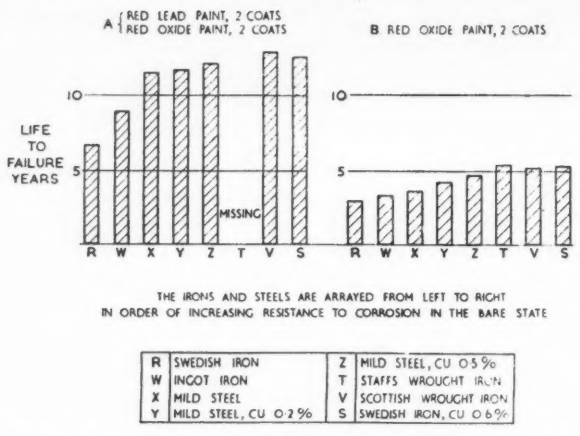
A { RED LEAD PAINT, 2 COATS
RED OXIDE PAINT, 2 COATS
B RED OXIDE PAINT, 2 COATS
LIFE TO FAILURE YEARS
10
5
MISSING
R W X Y Z T V S
THE IRONS AND STEELS ARE ARRAYED FROM LEFT TO RIGHT IN ORDER OF INCREASING RESISTANCE TO CORROSION IN THE BARE STATE
R SWEDISH IRON
W INGOT IRON
X MILD STEEL
Y MILD STEEL, CU 0.2%
Z MILD STEEL, CU 0.5%
T STAFFS WROUGHT IRON
V SCOTTISH WROUGHT IRON
S SWEDISH IRON, CU 0.6%

Figure 2—Correlation between paint durability and corrosion resistance of the basis iron or steel. (Exposure at Sheffield in an industrial atmosphere.)

from which mill scale had been removed by pickling or sandblasting. On such surfaces the life of the four-coat painting scheme A exceeded 10 years, being slightly greater for sandblasted than for pickled specimens. The least satisfactory results was obtained from a surface prepared by weathering and wire brushing, for which the low life of little more than two years was observed. Painting over the intact mill scale gave intermediate results—a life of about eight years—but it should be emphasized that on an experimental scale it was possible to take special precautions—which would be impracticable under production conditions—to retain the mill scale intact and undamaged.

The tests gave a less definite answer to the second question, the effect of the basis metal. Evidence was obtained that the performance of a painting scheme could be influenced by the basis metal but that this effect was only marked in the case of highly corrosive industrial atmosphere. For example, at Sheffield a good correlation was noted between the petroleum of the painting schemes on different irons and steels and the resistance of those irons and steels to atmospheric corrosion when exposed in the bare conditions. (See Figure 2.) On the other hand, in less corrosive atmospheres no pronounced difference in paint durability was observed on different basis metals. Thus, the average durability at all the exposure stations for painting scheme B (red oxide paint, 2 coats) on descaled surfaces, was 5.7 years for ordinary steel, as compared with 6.0 years for copper-bearing steel.

TABLE I. Effect of Surface Preparation on the Durability of Protection by Painting

Surface Preparation	DURABILITY, YEARS	
	A	B
	Red lead, 2 coats Red oxide, 2 coats	Red oxide, 2 coats
Intact Mill Scale	8.2	3.0
Weathered and Handcleaned	2.3	1.2
Pickled	9.6+	4.6
Sandblasted	10.3+	6.3

The results are average figures for about 16 painted specimens of different irons or steels exposed in an industrial atmosphere at Sheffield.

Another feature of this early work was the demonstration of the value of using inhibitive priming paints. This is brought out by the results shown in Table II, which relates to a variety of painting schemes applied to iron or steel exposure stands, weighing about 2 cwt each, in use at Llanwrtyd Wells. The average life of six painting schemes was 3.6 years when a red lead priming paint was used, but only 2.3 years when the red lead priming coat was replaced by a coat of non-inhibitive finishing paint. This experiment may be regarded as a good practical test, because the painting was carried out at the site by contractors.

1.2. Tests by the Protective Coatings (Corrosion) Sub-Committee.

One of the first tasks of the Protective Coatings (Corrosion) Sub-Committee was to make a more detailed study of the effect of different methods of surface preparation in order to decide, for example, whether variations in the methods of pickling, such as the use of different acids, concentrations or temperatures, were of significance. An extensive investigation of these and other factors was made on behalf of the Sub-Committee at the L.M.S. Research Laboratories at Derby[5] and the results have formed the subject of a report by one of the authors.[3] The main conclusions were:

1. Differences in paint performance due to different pickling processes were small, provided that the pickling bath was efficient. The best all ground results were obtained by descaling in 5 percent sulphuric acid at 80 degrees C, followed by immersion in 2 percent phosphoric acid at 80 degrees after an intermediate rinse in hot water.
2. Unsatisfactory results were obtained when the pickling process did not remove mill scale completely from the specimens, as was the case for certain spent baths that were allowed to operate for a fixed time. It appeared that such baths would not prove highly injurious if they were capable of removing the mill scale completely and sufficient time were allowed for them to do so, although this would be bad pickling practice.
3. The addition of inhibitors to hydrochloric and sulfuric acid pickling baths was beneficial in reducing metal loss on pickling and seemed to increase the durability of the protective paint.
4. The temperature of the bath and the use of a lime water wash after pickling had no marked

TABLE II. Value of Inhibitive Priming Paints for Steel

Paint A	DURABILITY, YEARS		
	Paint A, 3 coats	Lead Chromate, 1 coat Paint A, 2 coats	Red Lead, 1 coat Paint A, 2 coats
Red Oxide	3.1	3.2	3.0
Micaceous iron ore	2.7	3.8	3.2
Micaceous with Aluminum	2.9	4.0	4.1
Mineral Black	0.9	1.7	1.5
Bituminous, Black	2.7	3.5	3.5
Bituminous, Red	1.2	2.9	4.1
Average	2.3	3.2	3.6

effect on the results but both have certain practical advantages.

5. Storage indoors between pickling and painting had a negligible influence on the effective life of painting schemes but storage outdoors, permitting rusting, proved decidedly injurious.
6. Mechanical methods of descaling by blasting or grinding gave results equal to those obtained by the best pickling processes.

It should be noted that the Derby tests did not cover phosphating processes proper or flame-cleaning. These processes were not extensively used for structural steelwork at the time the experiments were begun.

1.3. Investigations of Joint Technical Panel J/P1: Paints for Structural Steelwork.

The investigation of Joint Technical Panel J/P1—Paints for Structural Steelwork—are devoted to three broad aspects:

1. The formulation of protective paint schemes for structural steelwork exposed to atmospheric corrosion with particular reference to the composition of priming paints;
2. The further study of methods of surface preparation, including methods newly introduced for this purpose; and
3. The formulation of painting schemes for use in conjunction with protective metallic coatings on steel.

Four series of tests have already been begun with these ends in view.[4] Their essential features are shown in Table III. In all of them 15 in. x 10 in. specimens, prepared by weathering either as-rolled or pickled steel plate, have been painted with two-coat painting schemes and exposed in the open at 450 degrees to the horizontal at Derby (an industrial atmosphere) and Brixham (a marine atmosphere). A unit stand holding 10 specimens is shown in Figure 3.

1.3.1. First Test Series.

One hundred priming paints were prepared for the first test series, both the pigmentation and the medium being varied. Twelve pigments and 12

TABLE III. Schedule of Research Projects: Joint Technical Panel J/P1

Test Series No.	TITLE and OBJECT	Exposure Commenced
1	**Priming Paints** The formulation of priming paints for the protective painting of structural steel.	1945
2	**Metallic Pigments and Lead Soaps** The use of metallic pigments in priming paints for structural steel, coupled with preliminary studies of the effects of soap formation on the properties of priming paints.	1947
3	**Surface Preparation and Metallic Coatings** A study of the effects of surface preparations prior to painting on the degree of protection afforded to structural steel by painting schemes and the formulation of priming paints for application over metallic coatings.	1948
4	**Bituminous and Tar Paints** The formulation of protective schemes for structural steel based on bituminous and tar paints used both as priming and as finishing coats.	1948

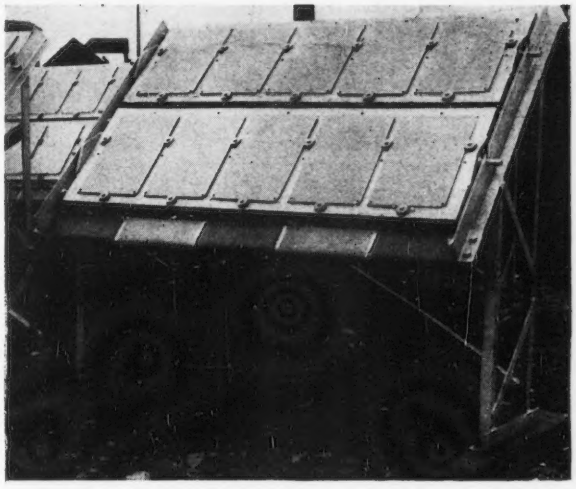

Figure 3—Unit exposure stand. Joint Technical Panel J/P1.

PIGMENT PER CENT BY WEIGHT		MEDIUM A1	B1	E1
BASIC LEAD SULPHATE 60, ASBESTINE 40,				
& BARIUM CHROMATE	20	◉	○	×
& BASIC LEAD CHROMATE	20	●	○	×
& ZINC CHROMATE	20	●	○	×
BASIC LEAD SULPHATE 40, ASBESTINE 20,				
& CHROMATED WHITE LEAD	40	◉	○	×
& FERROUS AMMONIUM PHOSPHATE	40	◉	○	×
& RED LEAD	40	◉	○	×
& ZINC TETRAHYDROXY-CHROMATE	40	●	×	○
BURNTISLAND RED 60				
& BARIUM CHROMATE	20	◉	×	×
& BASIC LEAD CHROMATE	20	◉	×	×
& ZINC CHROMATE	20	●	○	×
BURNTISLAND RED 40				
& CHROMATED WHITE LEAD	40	◉	×	×
& FERROUS AMMONIUM PHOSPHATE	40	○	×	×
& RED LEAD	40	◉	○	×
& ZINC TETRAHYDROXY-CHROMATE	40	◉	○	○
ZINC OXIDE 60				
& BARIUM CHROMATE	20	◉	◉	×
& BASIC LEAD CHROMATE	20	●	○	×
& WHITE LEAD	20	◉	◉	○
& ZINC CHROMATE	20	●	◉	○
ZINC OXIDE 40				
& CHROMATED WHITE LEAD	40	●	◉	○
& FERROUS AMMONIUM PHOSPHATE	40	●	○	◉
& RED LEAD	40	◉	×	○
& ZINC TETRAHYDROXY-CHROMATE	40	●	○	◉
RED LEAD 80 ASBESTINE 20		●	○	×
RED LEAD 40 WHITE LEAD 40 ASBESTINE 20		●	○	○

THE RESULTS RELATE TO 2 5 YEARS' EXPOSURE

RED LEAD IN LINSEED OIL (STANDARD) ●

KEY

1 THE CONDITION OF THE 2-COAT PAINTING SCHEMES (1 PRIMING COAT, 1 STANDARD FINISHING COAT) IS SHOWN THUS :

● ◉ ○ ×

BEST ⟶ WORST

THE GRADINGS ARE AVERAGE FOR 2 SPECIMENS AT DERBY AND 2 AT BRIXHAM

2 PARTICULARS OF THE MEDIA ARE:
A1 LINSEED STAND OIL/ALKALI-REFINED LINSEED OIL
B1 LINSEED/ALKYD
E1 COUMARONE TYPE 1

Figure 4. Interim results of first test series. Joint Technical Panel J/P1.

media were used, as shown in Table IV. Most of the pigments were not used singly but as components of ternary mixtures with another pigment and asbestine, which was adopted as a standard extender. In addition to well known pigments, such as red lead and red oxide, some newly introduced materials, such as ferrous ammonium phosphate and zinc tetrahydroxy-chromate, were included in the tests. The

TABLE IV. Schedule of First Test Series: Joint Technical Panel J/P1

12 Pigments	12 Media
Asbestine (extender)	Linseed stand oil/refined linseed oil
Barium chromate	Linseed/alkyd. Type 1
Basic lead chromate	Linseed/alkyd. Type 2
Basic lead sulphate	Tung/linseed/alkyd.
Burntisland red	Linseed/rosin/maleic
Chromated white lead	Linseed/pentaerythrityl/alkyd.
Ferrous ammonium phosphate	Reduced phenolic. Type 1
Red lead	Reduced phenolic. Type 2
White lead	100 percent phenolic.
Zinc chromate	Coumarone Type 1
Zinc oxide	Coumarone Type 2
Zinc tetrahydroxy-chromate	Natural resin

The above were used to prepare 100 different priming paints of known formulation.

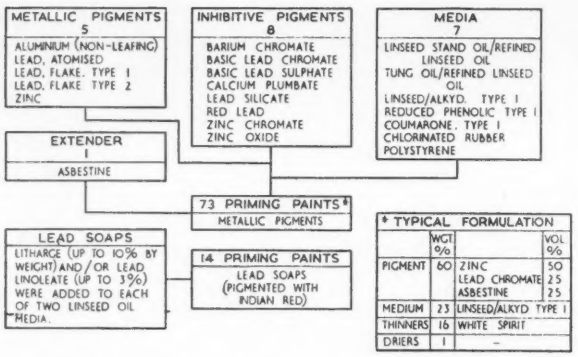

Figure 5. Schedule of second test series. Joint Technical Panel J/P1.

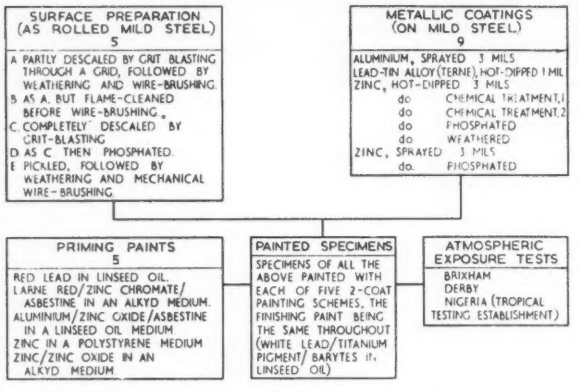
SURFACE PREPARATION (AS ROLLED MILD STEEL)
5
A PARTLY DESCALED BY GRIT BLASTING THROUGH A GRID, FOLLOWED BY WEATHERING AND WIRE-BRUSHING.
B AS A. BUT FLAME-CLEANED BEFORE WIRE-BRUSHING.
C COMPLETELY DESCALED BY GRIT-BLASTING
D AS C THEN PHOSPHATED.
E PICKLED, FOLLOWED BY WEATHERING AND MECHANICAL WIRE-BRUSHING.
METALLIC COATINGS (ON MILD STEEL)
9
ALUMINIUM, SPRAYED 3 MILS
LEAD-TIN ALLOY (TERNE), HOT-DIPPED 1 MIL
ZINC, HOT-DIPPED 3 MILS
do CHEMICAL TREATMENT, 1
do CHEMICAL TREATMENT, 2
do PHOSPHATED
do WEATHERED
ZINC, SPRAYED 3 MILS
do. PHOSPHATED
PRIMING PAINTS
5
RED LEAD IN LINSEED OIL.
LARNE RED/ZINC CHROMATE/ ASBESTINE IN AN ALKYD MEDIUM.
ALUMINIUM/ZINC OXIDE/ASBESTINE IN A LINSEED OIL MEDIUM
ZINC IN A POLYSTYRENE MEDIUM
ZINC/ZINC OXIDE IN AN ALKYD MEDIUM
PAINTED SPECIMENS
SPECIMENS OF ALL THE ABOVE PAINTED WITH EACH OF FIVE 2-COAT PAINTING SCHEMES, THE FINISHING PAINT BEING THE SAME THROUGHOUT (WHITE LEAD/TITANIUM PIGMENT/ BARYTES IN LINSEED OIL)
ATMOSPHERIC EXPOSURE TESTS
BRIXHAM
DERBY
NIGERIA (TROPICAL TESTING ESTABLISHMENT)

Figure 6—Schedule of third test series. Joint Technical Panel J/P1.

media ranged from the conventional linseed oil type to a variety of the more recent synthetic resin types.

Each priming paint was applied to two specimens and the painting was completed by a single finishing coat of a white lead and barytes in linseed oil paint. Exposure was begun in November, 1945. It is intended to prepare a report in 1953, which will cover seven years' exposure. Meanwhile, some of the main results obtained after the first 2½ years are presented in Figure 4. These show observations on the three major media only, because the performance of the paints in all the other media was either bad or moderate.

This in itself is a remarkable feature of the results. Considered broadly, the group of priming paints in the older type of medium—linseed stand oil/alkali refined linseed oil—has proved far superior to any of the synthetic media tested. This may be partly explained by the effects of film thickness, because in these tests the thickest films were obtained with the linseed oil medium.

The results also show that there are several possible alternatives to the straight red lead priming paint commonly used for steel structures. One of these paints, at the foot of Figure 4, is, it is understood, to be adopted by the British Standards Institution as an alternative standard priming paint for steel. It is pigmented with 40 parts by weight of red lead, 40 parts of white lead, and 20 parts of asbestine and the medium is a blended linseed oil.

1.3.2. Second, Third and Fourth Test Series.

Pending the publication of the 1953 report of Joint Technical Panel J/P1, little more can be done than to indicate the general scope of the other series of tests undertaken by the Panel.

The second test series, begun in April, 1947, is mainly concerned with two variables: the effect of metallic pigments and the effect of metallic soaps in priming paints. The three most common metallic pigments, aluminum, lead and zinc, were investigated. Lead was tested both as flake and powder, but aluminum is available only as flake and zinc only as powder. Moreover, as zinc alone of the three metals is certainnly inhibitive in itself with regard to steel, it was thought wise to blend the metallic pigments with a variety of inhibitive pigments.

Eight different inhibitive pigments were chosen, as shown in Figure 5, including calcium plumbate and lead silicate, which have recently become available. The pigment mixtures were incorporated in seven different media, including chlorinated rubber and polystyrene.

As it is probable that metallic soaps play an important part in the protective mechanism of priming paints, a preliminary study of this factor was made by preparing a series of priming paints in which the formation of lead soaps was deliberately induced by adding small percentages of litharge to the pigment or in which lead soaps were added *ab initio* as lead linoleate. These paints were pigmented with Indian red and were bound in two linseed oil media of low and high acid value, respectively.

The experimental program for the third test series is outlined in Figure 6. It is intended to cover the performance of newer methods of surface preparation of steel for painting, including phosphating, flame-cleaning and the application of metallic coatings. It does not follow that painting schemes designed for use on bare steel are also the most suitable where the steel is first covered with a protective metallic coating and information is needed regarding the best painting schemes for this purpose. As will be seen from Figure 6, three types of metallic coatings are under test—aluminum, "terne" (a lead-tin alloy), and zinc. These coatings were applied either by hot-dipping or spraying, or, in the case of zinc, by both processes. Five different methods of surface preparation for ordinary steel were also introduced, making the total number of surface preparations tested up to fourteen. To all these five different priming paints, selected from the previous tests, were applied. Exposure was begun in April 1948.

The fourth experimental program, also begun in April 1948, is devoted to a systematic study of paints based on coal tar pitches and on natural or petroleum bitumens. As indicated in Figure 7, 54 paints were prepared, including 18 tar paints and 12 bitumen paints of the solvent type, 12 bitumen paints blended with drying oils and 12 pigmented bituminous paints. In the last case a mixture of barium chromate, witherite and talc was used for the priming coat and the finishing coat was pigmented with aluminum of the leafing type.

1.4. *Investigations of Joint Technical Panel N/P2—Anti-Corrosive Compositions.*

The yearly work of the Marine Corrosion Sub-Committee on the formulation of anti-corrosive compositions for ships' hulls and underwater use, has formed the subject of paper to the Oil and Color Chemists Association and it is unnecessary to reiterate the details here.[5] It may be recalled that, as a result of systematic studies of various combinations of pigments and of media, the authors were able to advance some anti-corrosive formulations which are capable of a good general level of practical performance. One of these, anti-corrosive composition No. 173, has been adopted by the Admiralty as a standard bottom paint for new construction; another, anti-corrosive composition No. 185, is being used with satisfaction in the Merchant Navy, and in particular, has been applied to the bottoms of the "Queen Mary" and the "Queen Elizabeth."

Both paints are in a modified phenol-formaldehyde/linseed stand oil medium; they differ in that No. 173 is pigmented with basic lead sulphite, white lead, Larne red* and barytes; whereas, in No. 185, aluminum takes the place of white lead.

The presence of aluminum in No. 185 gives this composition certain advantages, notably, better brushability and can stability. The first tests undertaken by Joint Technical Panel N/P2 were, therefore, designed to ascertain whether a further improvement in performance could be achieved by blending both formulations.[6] A systematic study was made, in which the two basis pigmentations were combined, as shown in Figure 8. Moreover, the opportunity was taken of varying the medium. An anti-corrosive composition, No. 655, pigmented with basic lead sulphite, aluminum, Larne red and barytes in the same way as No. 185, but in which a mixture of equal parts of linseed stand oil and tung oil was used for the preparation of the medium instead of linseed stand oil alone, gave even better performance than anti-corrosive composition No. 185 itself.

It may be added, without going into detail, that the performance of these anti-corrosive compositions is checked, as a matter of policy, by service tests on liners placed at the sub-committee's disposal through the courtesy of shipping companies.

The most recent research of Joint Technical Panel N/P2, begun in September 1951, is concerned with maintenance repainting. By far the greater quantity of paint applied to a ship's hull throughout her life is used for maintenance and is put on in dry dock. The question, therefore, arises as to how the anti-corrosive compositions developed by the sub-committee behave when overpainted with the quicker drying paints that have to be used in dry dock. To answer it, steel specimens have been painted with anti-corrosive compositions Nos. 173 and 655, and immersed from a raft at Caernarvon. There they will be repainted at six monthly intervals with each of four different anti-corrosive compositions formulated to resemble the quick drying types of anti-corrosive composition used for maintenance in dry dock.

* "Larne red" is an iron oxide pigment obtained from a bauxite residue by special treatment. It was formerly known as "Burntisland red," the name which appears in Figure 4 and Table IV.

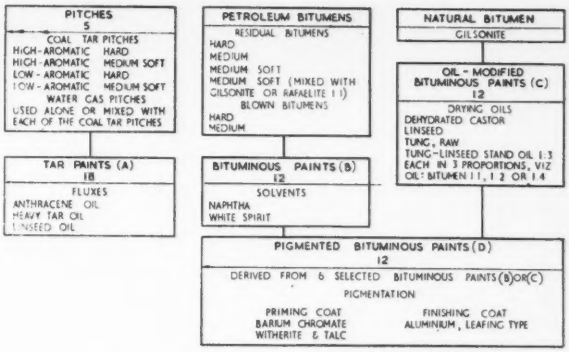

Figure 7—Schedule of fourth test series. Joint Technical Panel J/P1.

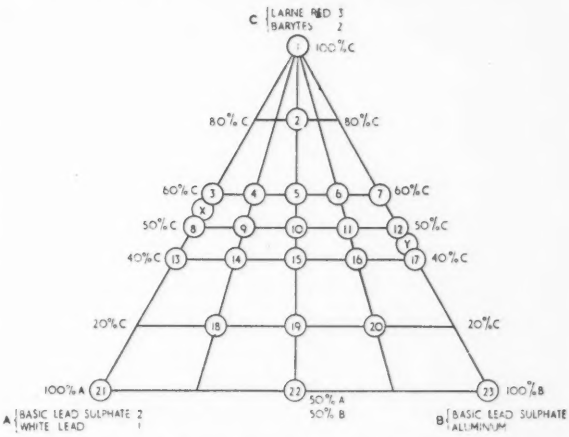

Figure 8—Research on anti-corrosive compositions. Joint Technical Panel N/P2. This diagram shows the proportions by volume of the pigment mixture. Points X and Y correspond to a/c compositions No. 173 and 185, respectively; A and B to the essential pigments in these paints and C to the extender. Twenty-three compositions were made as shown in each of two media: a) modified phenolformaldehyde/stand oil. b) coumarone/stand oil. Pigment mixtures X, 10 and Y were also bound with five other media.

TABLE V. Comparative Resistance of Zinc and Iron to Atmospheric Corrosion

Exposure Station	Type of Atmosphere	Number of Observations	Annual Corrosion Rate Mils Per Year		Ratio*
			Iron	Zinc	
Apapa, Nigeria	Tropical	15	1.12	0.049	23
Calshot	Marine	18	3.07	0.134	23
Congella, S. Africa	Marine-industrial	16	4.46	0.199	22
Derby	Industrial	4	6.94	0.276	25
Llanwrtyd Wells	Rural	19	2.51	0.118	21
Sheffield	Industrial	17	5.41	0.630	8.6
Dove Holes Tunnel	Railway Tunnel	6	3.38	3.02	1.1

* The ratio tends to be below the average when the metals are exposed in certain industrial atmospheres, e.g. Sheffield. Moreover, as is shown by the results for the Dove Holes Tunnel, zinc is practically as corrodible as iron when enclosed in humid spaces heavily polluted with sulfur gases.

2. Protection by Means of Metallic Coatings

2.1. *General.*

Many non-ferrous metals are more resistant to

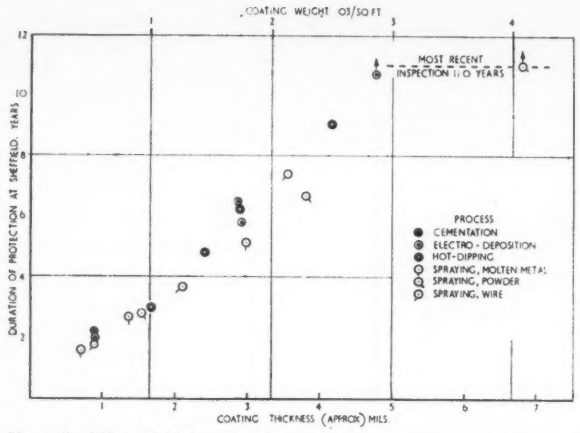

Figure 9—Effect of thickness on the protective efficiency of zinc coatings.

corrosion than iron. For example, in the open atmosphere, zinc is roughly 20 times less corrodible than steel, as is demonstrated by the experimental results shown in Table V. It is not surprising, therefore, that coatings of non-ferrous metals are widely used for the protection of iron and steel. The use of tin or zinc for this purpose, as in tinplate or galvanizing, goes back to medieval times. Until recently, however, the tendency was to use such metallic coatings for special purposes on relatively small articles, such as cans or buckets and their employment for structural steel was uncommon. Within the last twenty years, there has been a decided change in attitude and it is becoming common practice to use metallic coatings on important steel structures. This change has been rendered possible by developments in the methods of applying coatings to steel. Whereas galvanizing and electrodeposition are of necessity limited to articles that can be immersed in the processing baths, the introduction of metal spraying has rendered it possible to apply a metallic coating to the largest objects. Moreover, during the last half century, the introduction of alternative coating metals, notably of aluminum, has greatly enlarged the possibilities of this method of protecting steel.

2.2. First Series of Tests (1940)

To explore the value of protective metallic coatings for heavy structural steel, the Protective Coatings Sub-Committee began an extensive investigation in 1940, in which coatings of seven different metals or alloys were applied by a variety of processes to heavy mild steel plates.[7] Three coating thicknesses were tested as a rule and the coated specimens were exposed in several typical atmospheres. A few tests were also made by immersion in the sea.

TABLE VI. Schedule of Tests on Protective Metallic Coatings—First Series

Coating Metal	Process	Exposure Stations
Aluminum	Cementation	**Atmospheric:**
Cadmium	Electrodeposition	Calshot
82/18 Cadmium-Zinc Alloy	Hot-dipping	Llanwrtyd Wells
Lead	Spraying, molten metal	Sheffield
88/12 Lead-Tin Alloy	Spraying, powder	Apapa, Nigeria
Tin	Spraying, wire	Congella, S. Africa
		Marine:
Coating Thickness: 1, 3 or 5 mils (nominal)		Gosport and Emsworth

A schedule of the tests is shown in Table VI. It will be seen that the seven coating metals were aluminum, zinc, cadmium, tin, lead, zinc-cadmium alloy and lead-tin alloy. Where applicable to the particular metal, the coating was applied by each of the following processes: hot-dipping, cementation, electrode-position, spraying by the molten metal pistol, spraying by the powder pistol, and spraying by the wire pistol.

The results of tests in the sea are briefly that zinc gave better protection than aluminum. A zinc coating five mils thick (3 oz. per sq. ft.) had a useful life of about six years.

The atmospheric tests are still in progress, as several of the coatings have not yet failed. The main observations made so far are:

1) The duration of protection yielded by zinc coatings was roughly proportional to their thickness and the process of application played, at most, a secondary part. This is evident from the results shown in Figure 9, which relate to an industrial atmosphere at Sheffield.

2) Sprayed aluminum coatings applied by the wire pistol or the molten metal pistol gave good protection. A coating of 0.8 oz. per sq. ft. of aluminum (3.6 mils thick) should have an effective life of five years at Sheffield. Approximately the same coating thickness, 2.9 mils (1.7 oz. per sq. ft.) of zinc is needed to give the same life.

3) Lead coatings gave good results at Sheffield but they failed relatively rapidly in non-industrial atmospheres at Llanwrtyd Wells and Calshot. This difference in behavior is due to the formation of a protective film, presumably of basic lead sulfite, in the highly polluted Sheffield atmosphere.

With regard to the first of these conclusions, it should be added that the British Non-Ferrous Metals Research Association has obtained experimental evidence that the protective value of a zinc coating is enhanced when it contains an iron-zinc alloy layer.[8] For practical purposes, this means that for equal thickness zinc coatings applied by hot-dipping or cementation, which contain iron-zinc alloy layers, should prove superior to zinc coatings applied by electrodeposition or spraying, which consist essentially of unalloyed zinc. To resolve the conflict between the two series of experiments, the Protective Coatings (Corrosion) Sub-Committee has undertaken, in collaboration with the British Non-Ferrous Metals Research Association, a further series of exposure tests on specimens with coatings in which variations in the iron-zinc alloy content of the coating from nil upwards have been introduced deliberately by suitable heat treatments. These tests were begun in 1948 and no conclusions have yet emerged from them.

Sprayed aluminum coatings seem to be of particular value in humid and polluted atmospheres where zinc coatings are often of limited application, because of the deliquescence of the zinc corrosion product. This difference is illustrated by the photographs shown in Figure 10 of some small metal coated specimens which were subjected to tests at the Post Office Research Station in an accelerated corrosion cabinet polluted with the combustion products of coal gas artificially enriched with sulfur.

2.3. Second Series of Tests (1951).

The second series of tests on metallic coatings was undertaken with two objects in view:

1. It was desirable to repeat tests on sprayed aluminum coatings applied by the powder pistol. These had given disappointing results in the first series of tests but it was found that the coating metal contained an appreciable quantity of copper, which may have accounted for the unsatisfactory protective properties.
2. The opportunity was taken to include several coating metals or processes that had been developed since the first tests were planned in 1939. In particular, alloys of zinc and aluminum or of aluminum and magnesium were used as coating metals. This was done to study whether variations in the potential difference between the coating metal and the bare steel would affect the degree of electrochemical protection afforded at breaks in the coating.

A schedule of these tests is given in Table VII. It is hoped that an interim account of this investigation, together with a report on the results of the first series of tests on metallic coatings, covering the first ten years' exposure, will be published in the course of the next year.

3. Protection by Miscellaneous Coatings

The Protective Coatings (Corrosion) Sub-Committee has also undertaken a limited amount of work on protective coatings other than paints or non-ferrous metals.[9] These have shown vitreous enamel to be of particular value. This material is practically inert and has good resistance to a combination of highly corrosive atmospheres with moderately high temperatures. Unfortunately, the usefulness of vitreous enamel is limited by the practicability of applying it to the article, because, apart from the difficulty of dealing with heavy sections, the coating has to be fused at a temperature of about 900 degrees C. The heating introduces complications such as distortion and changes in the mechanical properties of the steel itself. Moreover, liability to damage by chipping is a disadvantage, although, this has been greatly reduced by the introduction of the modern thinner enamels.

TABLE VII. Schedule of Tests on Protective Metallic Coatings—Second Series

Coating Metal	Notes and Objects of Tests
Aluminum	Used in 3 grades of purity: 99.0, 99.5 and 99.9 percent Al.
Aluminum-Copper Alloys	With 0.5 and 2.5 percent Cu. To study the effect of the purity of the coating
Aluminum-Magnesium Alloys	With 5 and 15 percent mg.
Aluminum-Silicon Alloy	With 5 percent Si. Also applied by hot-dipping
Aluminum-Zinc Alloys	With 5, 15, 85 and 95 percent Zn.
Nickel-Zinc	Heat-treated electrodeposits (The "Corronizing" process)
Tin Zinc Alloy	With 22 percent Zn. Also electrodeposited.
Zinc	To assess and compare the protective value of these coatings including aluminum.

Note. Most of the coatings were applied by spraying both with the powder and the wire pistol to a standard thickness of 3 mils (0.003 in.)

Figure 10—Laboratory test specimens after 192 days' exposure. (Post Office Research Station.) Top row: Sprayed aluminum, 3 mils thick. Bottom row: Hot-dipped zinc, 3 mils thick. The right hand specimen of each pair also received a single coat of stoving paint C.S. 2219. The test consists essentially in exposure to water spray in an atmosphere containing 20 ppm of sulfur dioxide.

Liability to damage is also the main drawback of such coatings as asbestos-cement, or bitumen mastics. Difficulties in ensuring adhesion and complete water tightness militate against purely enveloping coatings of polythene sheet and the like. Where these difficulties can be overcome, such coatings are undoubtedly of value for particular applications.

4. Conclusions

Great strides are being made in the development and application of protective coatings for iron and steel, and it may fairly be claimed that the work of the Protective Coatings (Corrosion) Sub-Committee has served, and will continue to serve, a valuable purpose in investigating such coatings and in mak-

ing an impartial assessment of their relative values. It would seem that further research is desirable in the following directions:

1. **Surface Preparation of Metallic Coatings for Painting.** The old difficulty of securing good adhesion of paint to newly galvanized sheet is well known. Similar difficulties arise when painting over non-ferrous metal surfaces and it is often usual to overcome these by using a chemical surface treatment. There is need for systematic investigation of these chemical surface treatments and also of the formulation of the most suitable protective paints for application to metallic coatings.

2. **Blistering of Paint Films.** The blistering of paint films, more particularly of ships' bottom compositions is still imperfectly understood despite notable work by members of the Association and others. There is room for consistent and systematic research in this field.

3. **Phosphate Coatings.** Many factors still need clarification relating to the use of phosphate coatings, particularly when phosphating processes are applied to structural steel. Reliable specifications and performance tests would be of particular value.

4. **Plastic Coatings.** Subject to the comments about adhesion and damage made in the previous section, there is clearly a considerable future for enveloping protective coatings of plastic material applied by spraying or other means. The production of successful coatings of this type involves both development and testing.

Finally, the authors would emphasize the necessity for adequate supervision of protective processes in industry. It is useless to adopt the best and most modern protective processes unless they are applied under correct and well controlled operating conditions. Phosphating processes especially can only be fully effective if carried out under rigid control. Moreover, emphasis should be laid on the damage that may result by trying to rush coating application under tight production conditions.

References

1. United Nations Scientific Conference on the Conservation and Utilization of Resources. Lake Success. 1949.
2. First, Second, Third, Fourth and Fifth Reports of the Corrosion Committee. Iron and Steel Institute Special Reports Nos. 1 (1931), 5 (1934), 8 (1935), 13 (1936) and 21 (1938).
3. F. Fancutt. The Effects of Different Methods of Pretreating Iron and Steel Before Painting. Iron and Steel Institute Special Report No. 31 (1946).
4. Joint Technical Panel J/P1—Paints for Structural Steelwork. Second Interim Report. The British Iron and Steel Research Association, London. July 1949.
5. F. Fancutt and J. C. Hudson. "The Protection of Ships' Bottoms and the Formulation of Anti-Corrosive Compositions." *J. of the Oil and Color Chemists' Assn.* **30**, 135-162, 1947.
6. Joint Technical Panel N/P2—Anti-Corrosive Compositions. First Report. The British Iron and Steel Research Association, London. January 1950.
7. J. C. Hudson and T. A. Banfield. The Protection of Iron and Steel by Metallic Coatings. *J. of the Iron and Steel Inst.* **1946.** No. II. 229P-264P.
8. S. E. Hadden. Private communication.
9. J. C. Hudson and T. A. Banfield. The Protection of Steel by Various Non-Metallic Coatings. *J. of the Iron and Steel Inst.* **1948.** 99-110. (Jan.)

Dezincification Spot Test Solution★

*By F. A. PRANGE**

DEZINCIFICATION is still a frequent cause of failure of brass. Though inhibited Admiralty brass and Muntz metal may occasionally dezincify in such severe services as feed water deaerators, in an overwhelming majority of the cases dezincified specimens are not inhibited. As a means of identifying the materials especially subject to dezincification, a test solution was devised to differentiate between the resistant and susceptible materials.

The test solution used successfully since 1943 is the following:

$CuSO_4 \cdot 5H_2O$	50 g
$Na_2C_2H_3O_2 \cdot 3H_2O$	30 g
KCl	10 g
Glacial Acetic	15 ml
Water to make	400 ml

The solution may be used as a spot test medium. Used in this fashion, it is applied to a freshly abraded surface. An alternate is to dip the tube or other object in the solution. At room temperature, thirty-second exposure is enough to give a clear indication. Uninhibited brass becomes coated with metallic copper or a pinkish-gray deposit. Inhibited brass (arsenic, phosphorus, or antimony) becomes coated with a dark gray to black film. Until one becomes thoroughly familiar with the test, it is desirable to use known samples for comparison. The test gives unequivocal indications when used on clean metal.

In the process of checking this test, one of the reviewers found that 20 percent cupric chloride solution worked just as well as the solution proposed above. Because of its simplicity, the 20 percent cupric chloride solution is probably preferred.[1]

Reference

1. A. W. Tracy, American Brass Company, private communication.

★ Submitted for publication September 10, 1952.
* Phillips Petroleum Co., Bartlesville, Okla.

A REVIEW

Treatment of Recirculated Cooling Water*

By J. K. RICE*

Abstract

A comprehensive review of the published work since 1940 on the treatment of recirculated cooling water is presented. The results indicate that the level of knowledge concerning all the variables in the treatment of recirculated cooling water is about the same as the level of knowledge that existed 25 years ago in the internal treatment of boilers. For each of the several popular methods of treatment there can be shown many instances of both success and failure under apparently similar conditions. Considerable effort is presently being expended, however, in evaluating the relative effect of the variables involved and the next several years should see marked progress.

COOLING WATER has been used by industries for centuries and the problems of corrosion and fouling in cooling water systems are far from new. The chemistry of treating water to prevent corrosion and fouling has, until recently, kept pace with problems as they arose. But, in the last ten years and particularly in the last five years, available knowledge of cooling water treatment has lagged far behind demand.

The need for new techniques of corrosion prevention is partly a result of the recent vast increase in the use of recirculated cooling water systems. There are, at the same time, high performance demands placed on these systems. The decrease in both the quantity and quality of water available for cooling also contributes to the need for new methods of treatment. The growth of industries in areas of meagre supply, the gradual lowering of ground water tables and the advent of widespread use of air-conditioning have all accelerated the use of recirculating cooling systems.

The cost of corrosion has increased phenomenally, not so much because of equipment repair and replacement, but because of shutdown time of units necessitated by waterside corrosion and fouling.

One purpose of this paper is to review in detail the variables which affect the rate of corrosion and fouling in recirculated cooling water systems. It is further a purpose to describe the more common methods of treatment used to reduce the rate of corrosion and fouling. Throughout this paper the use of the words 'recirculated cooling water systems' means 'oxygen saturated (or nearly saturated) recirculated cooling water systems.' This paper, therefore, describes specifically cooling tower systems.

The major variables which affect corrosion rates and which are common to all recirculated cooling water systems are: the velocity, viscosity, dissolved solids concentration, temperature and pH of the water in the system. A discussion of these first is helpful in understanding the methods of treatment.

The Effect of Velocity

The first effect of increasing velocity in most natural waters is to increase the corrosion rate.[1] Because film coefficients vary as the 0.8 power of the velocity, the diffusion rates of O_2 and cations to the metal surface are increased. When very high velocities are attained the corrosion rate is again diminished. This is thought to be caused by the oxygen polarization of the cathodic areas. Because polarized cathodic areas are more noble than non-polarized cathodic areas, a galvanic cell is formed between adjacent areas of low and high velocity. This accounts for instances, (in which the shell and tube are constructed of steel) of serious pitting at the tube ends and in the water box, but not of the tube itself. High velocity can have just the reverse effect, however. Whenever inhibition of corrosion results from formation of a deposit on the anodic areas, the action of high water velocities is to remove this deposit. Corrosion proceeds rapidly at these unprotected points. The efficiency of anodic inhibitors, which function by altering the electron configuration of the surface metal atoms is increased by increased velocity. The increased velocity reduces corrosion rate by both removing undesirable deposition products which reduce the access of the inhibitor to the metal surface and by increasing the film coefficient of the inhibitor, allowing higher diffusion rates.

Effect of Viscosity

The usually conceived viscosity of the media in a cooling system is the viscosity of the solution body. Actually, it is the viscosity at the interface that is of importance. This viscosity can be greatly different from that in the main body of solution. The effect of increasing viscosity is to decrease the diffusion coefficient[2] of the ions at the interface. Since the reduced diffusion coefficient reduces the overall transfer rate of ions taking part in the electrode reaction, it will reduce the corrosion rate. Strongly surface active materials, therefore, that also increase viscosity, can decrease the corrosion rate materially. The action of certain colloidal silicates in reducing cor-

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rosion can be attributed to just such a mechanism. To be most effective, the action should be cathodic in nature. Crystalloidal silica, on the other hand, has an anodic action by forming insoluble iron silicate on the anodic areas.[3, 4] Long chain organic compounds containing a highly polar group at one end have the action of blanketing the metal surface with a dense film,[5, 6] and thus they decrease corrosion rate by decreasing the diffusion rate of ions to the surface.

Effect of Dissolved Solids

The effect of increasing the dissolved solids or increasing the ionic strength is generally two-fold: first, increasing dissolved solids increases slightly the solubility of low solubility compounds; calcium carbonate, calcium phosphate, etc. For calcium in particular, the pH increases 0.1 unit per each 10-fold increase in dissolved solids concentration; second, in dilute solutions increasing dissolved solids decreases slightly the diffusion coefficients of the ions.[7] The overall effect, however, is to increase the rate of corrosion wherever the rate of corrosion is under cathodic control.[8, 9] In those systems protected by anodic inhibitors, increasing dissolved solids does not increase corrosion rates.[10] This is true unless the dissolved solids increase is caused by or is accompanied by increased chloride concentration.[11] Chloride ions increase the corrosion rate by destroying passivity. Uhlig and Mears conclude that they do this either by preferential diffusion through the deposited film, or by preferential adsorption at favored areas, causing alteration of the electron configuration of the surface metal atoms with resultant decreased passivity. In the corrosion controlled by cathodic inhibition, increasing chloride at a constant ionic strength has little effect.

The Effect of Temperatures

The overall effect of increasing temperature on such complex chemical systems as are being dealt with is impossible to predict in advance, without knowing which of the various mechanisms involved is controlling the corrosion rate. There are six basic controlling factors that increasing temperature affects separately:

1) It increases the diffusion coefficient;
2) It changes the potentials of the electrodes;
3) It changes the solubility of the various compounds;
4) It increases the activity of the ions;
5) It increases the chemical reaction rates;
6) It changes the chemical equilibria.

For most systems under consideration, however, only the first three are important.

1. The diffusion coefficient, which will increase about 3 per cent per degree Centigrade increase
2. The electrode potential, which for iron in dilute solution will increase about .4 millivolt per degree C increase
3. The solubility of the compounds, the deposition of which is controlling the corrosion rate.

In all of the foregoing it is the temperature of the interfacial film that is of major importance. The temperature of the film on heat transfer surfaces of high transfer rates can be very markedly different from the temperature of the main body of solution.

The Effect of pH

The effect of pH is multi-fold. It changes the solubilities of all of the low solubility compounds. It directly affects the corrosion rates, because, as pH is lowered, the need for oxygen as a cathodic depolarizer decreases and hydrogen can become discharged directly. Therefore, it is necessary that the pH be controlled precisely.

Controlling pH and dissolved solids alone can be used to reduce the corrosion rate without the addition of any further chemicals to the system.

Micro-Organisms

Micro-organisms have a different effect on the corrosion rate from the system variables described above. Their presence or absence from systems has a great effect on the treatment required, however. Microbiological fouling on metal surfaces restricts flows and serves as a binder for otherwise non-adherent suspended matter. It also prevents the diffusion of oxygen to the surface and thereby promotes corrosion. When anodic inhibitors are being used, the fouling prevents their adsorption. In addition, the fouling often affords the oxygen barrier necessary for the formation of colonies of anaerobic micro-organisms underneath it, next to the metal surface. The sulfate reducing bacteria are probably the most important of the anaerobic micro-organisms commonly found in water systems. As cooling tower recirculating systems are oxygen-saturated, these bacteria are found only under deposits or other fouling, where essentially anaerobic conditions exist.[12] They accelerate the corrosion process at anodic areas through the products of their metabolic action.

An important species of micro-organism found in water systems is that of the iron bacterium. These bacteria require aerobic conditions and, therefore, can exist throughout the systems discussed. They require ferrous iron for their metabolic process, oxidizing it to ferric iron and forming the familiar tubercle. Their action in promoting corrosion is the action of this tubercle in preventing the diffusion of oxygen or protective inhibitor to the metal surface. Colonies of anaerobic sulfate reducing bacteria have been found to form within these tubercles.

The control of these micro-organisms can be accomplished by feeding chlorine to the recirculating systems.[14, 15] The usual practice is either to feed the chlorine every other day to a .5-1.0 ppm. residual in the system or to feed chlorine continuously to maintain a 0.3-0.5 ppm. With constant chlorine feed, a heavy feed to a higher residual of 1.0-2.0 ppm is used every 2 to 10 days. Failure to maintain a chlorine residual for several days can result in the formation of anaerobic bacteria colonies under deposits in the system. Re-establishment of a chlorine residual does not necessarily kill all these colonies because the chlorine cannot always diffuse through

the deposit. Control of these micro-organisms can be accomplished also feeding certain quarternary amines, chlorinated phenols, bromines, potassium permanganate, or dyes.[16, 17]

Many methods of treatment have been used to prevent corrosion in recirculated cooling water. There are now seven popular methods of chemical treatment. Each method depends on control of both pH and dissolved solids, in addition to the specific chemical addition.

pH Control, Dissolved Solids Control

A particular pH and dissolved solids concentration is established to accomplish either one or two different methods of corrosion control:

1. To deposit a thin dense adherent film of calcium carbonate over all surfaces, particularly the cathodes.
2. To deposit a thin dense adherent film of ferrous-ferric oxide on the anodes.

Method (1) is most popularly known as 'controlled deposition,' using Langelier's Saturation Index.[18] This method has been in use for many years and, while it is highly successful sometimes, it often fails completely. Basically, it requires establishment of certain conditions in which the solution is saturated with calcium carbonate at the temperatures in the interfacial film. Most failures can be attributed to porous films or excessive scale formation.

Multiple-pass heat exchangers that operate with product side temperatures of 400 to 600 degrees F. and with outlet water temperatures of 180 to 190 degrees F. are the most difficult to protect. When control of the system is based on the temperature of an intermediate pass, heavy corrosion can result in the first pass, with heavy depositions in the last pass. Caution should be used in the application of this method of corrosion control in any system in which the inlet and outlet water temperatures cause a variation in the saturation index of over 0.5 pH units.

Powell, Bacon and Hill[19] furnish a very detailed summary, based on the study of a number of failures of the method.

The second method above, the deposition of an adherent, dense, iron oxide film, should be a very simple and effective treatment, where the make-up water to the system is either externally softened or naturally low in hardness. There are, however, probably equal numbers of successes and failures for this type of treatment insofar as corrosion prevention is concerned. Because this type of protection relies entirely on the formation of a relatively impermeable mixed iron oxide film, the very variable character of such film makes prediction of results in advance almost impossible. Insufficient chlorination for even a short period, as mentioned previously, will permit growth of various anaerobic bacteria colonies to begin under the layer of iron oxide covering the anodes. High chloride ion concentration can accelerate corrosion and pitting at points of penetration of the film.[20] Various organic materials in solution, such as tannins, hydrocarbonates, slimes, etc., can cause the deposit to be porous in places, which spots are then subject to intense attack. It is indicated, however, that if the make-up water is externally treated to give hardness less than 12.0 ppm, turbidity less than 5 ppm and the system is maintained with a free chlorine residual of 2 ppm, chloride ion less than 150 ppm, the number of concentrations about 5 to 7 and pH 7.5-8.0, corrosion can be controlled.

Silicates

The addition of silicates for corrosion control has had wide use, nevertheless, the results are unpredictable. Evans[21] indicates that the mechanism affording the protection is under anodic control and that this control is achieved by the formation of a dense, adherent film of deposited ferrous silicate. Lately, the theory advanced has been that the protection is by a rather gelatinous film of mixed ferrous oxide and colloidal silica. Again, protection is dependent on the relative density of the film. This type of corrosion inhibition is subject to the same difficulties that plague iron oxide films, i.e., extraneous foreign matter, organics, bacteria, etc. that produce a relatively porous film. In this method there is the added difficulty of keeping the film of uniform thickness and of preventing excessive deposition in areas closest to the point of application of the treatment. If heavy deposits are formed in the high temperatur ezones, they are extremely hard and are difficult to remove. The actual form of silica in solution apparently has marked effect on the success or failure of this type of treatment. Until the exact form required is known the method of obtaining it and the method of analyzing for it, the use of silicates will continue to be by trial and error, though still a very attractive means of treatment from a cost standpoint.

It should be mentioned here that many instances of apparently successful straight pH control occur where makeup waters are high in natural silicas and it is quite possible that the particular form in which this silica exists is affording the observed successful control.

Chromates

Chromates have been widely used and widely investigated as a means of corrosion control. Two theories are currently presented as to its action in preventing corrosion. The more widely held one is the Generalized Film Theory, where the formation on the anodes of a thin, dense, adherent deposit of mixed ferric and chromic oxide produces passivity.[22]

The other theory proposed is the Electron Configuration Theory, wherein the chromate ions form an adsorbed layer on the iron anodes. The chromate film shares electrons from surface iron atoms, satisfies secondary valance forces, but does not disrupt the metal lattice.[23] This action renders the surface atoms of iron less active. The general practice has been to maintain 500 to 1000 ppm chromate for a period of ten days to a month, after which the concentration is dropped to 200 to 300 ppm and not less than 100 ppm.[24] The pH ranges from 7.5 to 9.5 and

is usually between 7.5 to 8.5. While this method has been very successful in controlling corrosion, it has several disadvantages. The cost of treatment for large towers, such as 35,000 gallons per minute circulating rate, can be $35.00 to $50.00 per day when using chromates. The nuisance value is high, particularly in congested areas, where spray under unusual wind conditions can cause shorting of transformer banks, damage to cars, clothes, etc. In systems using high hardness water for make-up, the formation of calcium carbonate deposits is troublesome in high temperature areas because of the relatively high pH of the system. Wherever there is a process leakage of materials containing oxidizable sulfurs, such as H_2S and mercaptans, the chromate is reduced to trivalent chromium, in which form it has no value as an inhibitor. As often happens in oil refinery operation and in certain textile and rayon operations there are process leaks that cannot be repaired promptly or would necessitate expensive shutdowns, the problem of high chromate consumption and/or increased corrosion should always be considered in selecting it as a means of treatment. It has the disadvantage that, when applied in concentrations of less than 100 ppm, it can cause severe pitting and tuberculation at points in the system of low velocity or relative inaccessibility.

Polyphosphates

Polyphosphates have several advantages as inhibitors: it passivates by adsorption; does not form objectionable precipitates with the cations in the system; prevents the precipitation of calcium carbonate by the threshold effect; is economical to use, requiring 10 to 15 ppm after the initial protection has been established. A few strong disadvantages, however, have outweighed its advantages for most recirculated cooling water systems. It has been found to be an unpredictable inhibitor. The protection it affords above 180 degree F. is not good.[25] Also, in systems operating in the pH range of 7.0-8.0, the orthophosphate that results from the reversion of the polyphosphate causes the precipitation of calcium phosphate in the higher temperature areas. Larson[26] presents the objection that polyphosphate depends so greatly on an appreciable rate of flow for its anticorrosive action that it is impractical to use it effectively in many systems. Another drawback is the difficulty in analyzing for polyphosphate. The present practice is usually to analyze for orthophosphate and from it to estimate the polyphosphate, using a fixed rate of poly to ortho. The use of polyphosphate, however, has worked well in recirculated cooling water systems of medium temperature range wherein the make-up water is low in hardness and turbidity. These cases permit the maintenance of a slightly negative Langelier index with the pH usually in the range of 7.0 to 7.5, so that depositions of both calcium carbonate and calcium phosphate in the higher temperature zones can be prevented.

Lately, Hatch[27] has pointed out that very satisfactory results have been achieved using polyphosphate at approximately 50 ppm, a pH of 6.0-6.5, in a system containing approximately 150 ppm of hardness, 103 ppm chlorides.

Chromates-Polyphosphates

Since one of the difficulties in the use of high chromates, with its associated pH of 7.5-8.5, has been deposition of calcium carbonate in higher temperature zones, polyphosphates have been added to such systems for some time.[28] The chromate is carried at a concentration of 300 to 500 ppm and is expected to furnish the corrosion protection. Polyphosphate is maintained at 5 to 15 ppm and is expected to furnish protection against the deposition of calcium carbonate. The method still produces many unsatisfactory conditions, one of which is the severe pitting action produced in inaccessible areas or areas of low flow. In addition, in the pH range used, there is reversion of the polyphosphate to orthophosphate, causing undesirable deposition of calcium phosphate in the high temperature zones.

In 1949 W. G. Palmer[29] published the results of considerable work at Cambridge University with the use of low concentrations of orthophosphate and chromate, also orthophosphate and persulphate. His conclusions confirmed his original theory that at points of low inhibitor concentration, a blister-like membrane forms which further prevents the access of inhibitor to these points. The low concentration of phosphate apparently causes a membranous precipitate of ferrous phosphate to form at some distance from the metal surface instead of on the surface itself. Palmer further found that with suitable mixtures of orthophosphate and strong oxidizing agents, such as persulphate or chromate, the pitting could be greatly reduced and the nature of the deposit on the anodes changed from one having a gelatinous appearance to one with a granular appearance. This would correspond with the formation of ferric phosphate, a crystalline non-membranous body.

A similar process would occur with chromates in low concentration, 50 ppm or thereabouts, except that in this case insufficient chromates would reach the surface to both oxidize all of the iron going into solution and to adsorb on and passivate the anodic areas. Subsequent work by Kahler and George[30] showed that orthophosphate chromate mixtures do not give as complete protection as polyphosphate chromate mixtures but better protection than chromate alone in the same concentration. They also showed the polyphosphate alone produced extremely vicious pitting and penetration much greater and much deeper than chromates alone.

The increased corrosion rate resulting because access of the inhibitor to the anodic areas is prevented indicates the mechanism of passivation is more in agreement with the electron configuration theory than the generalized film theory of passivity. It also helps to explain why polyphosphates generally have shown much more protection in areas of high velocity. Action of the polyphosphate when used with the chromate is apparently two-fold. It's partial reversion to orthophosphate furnishes a precipitating

ion for the ferric ion formed (orthophosphate only can be added for this part of the action), and it acts by chemical adsorption to produce passivity while the chromate, in this instance, can act both as an oxidizing agent and a passivator, it's primary action is to act as an oxidizing agent.

The foregoing suggests the possibility of using a less expensive oxidizing agent than either persulphate or chromate. One of the least expensive oxidizing agents available is chlorine and, fortunately, it is one that is available in most large recirculated cooling systems. Chlorine also would have the advantages of non-toxicity, availability, low nuisance factor and of presenting no waste disposal problem. The fact that chlorine and polyphosphate have already been used without notable effect (the chlorine being fed for slime or algae control) would suggest at first that more than just an oxidizing agent, such as chlorine, is required. However, it must be borne in mind that in instances where cooling systems are chlorinated, the level of chlorination is quite low, usually to residual of .5 ppm. Certain limited experience indicates that the use of a chlorine residual of 2.0 ppm, together with the proper polyphosphate in a concentration of 10 to 15 ppm at such a pH to prevent the deposition of calcium phosphate, is successful in arresting corrosion. The correct selection of the polyphosphate to be used would of course depend on the temperature, pH and hardness of the system.

Additional Methods

There are many methods of treatment in addition to the methods described here in detail. The results of the use of nitrites,[31] organic chrome compounds,[32] soluble oils,[33] and others have been published.

Summary

The effect of several variables on the corrosion rate of iron in recirculated cooling water systems has been presented. The order of magnitude of the effect of each has been included if it was available. Several popular methods of treatment to reduce corrosion rates have been described. It is apparent from the conflicting published information on the successes and failures of the different methods of treatment, that a tremendous amount of basic and applied research is necessary in the field of cooling water chemistry.

Acknowledgment

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References

1. H. H. Uhlig. Corrosion Handbook, p. 135. John Wiley & Sons, New York, 1948.
2. H. S. Harned and B. B. Owen. The Physical Chemistry of Electrolytic Solutions, p. 182. Rheinhold Publishing Corp., New York, 1950.
3. U. R. Evans. Soluble Inhibitors. *Ind. and Eng. Chem.*, **37** (1945).
4. O. C. Blumberg. Corrosion Control. *Amer. Water Works Assoc. J.*, **32,** 394 (1940).
5. C. A. Mann. Nitrogen Containing Organic Inhibitors of Corrosion. *Ind. and Eng. Chem.*, **39** (1947).
6. H. H. Uhlig. Fundamental Factors in Corrosion Control. *Corrosion*, **3** (1947).
7. *Ibid* (2).
8. M. Darrin. Corrosion Criteria—Their Visual Evaluation. *ASTM Bulletin* No. 138, p. 37, 1946.
9. *Ibid* (1).
10. Wilson & Groesbeck. Tests of Corrosion Inhibitors for Water Treatment in Air-Conditioning Equipment. *J. Res. Nat. Bur. of Stand.* **24,** 665 (1940).
11. *Ibid* (3).
12. *Ibid* (1).
13. G. B. Hatch. Proceedings of the 11th Annual Water Conference, p. 15; Engineers Society of Western Pennsylvania, Pittsburgh, 1950.
14. R. B. Conlan. Controlling Impurities in Air Conditioning Water. *Sou. Power & Ind.*, **66,** No. 8, 72 (1948).
15. James C. Deflon. Maintenance of Cooling Towers. *Petro. Ref.*, **27,** No. 5 (1948).
16. J. C. Albright. Process Gives Plant Water Free of Scale and Corrosion. *Petro. Ref.*, **29,** No. 7, 119 (1950).
17. H. E. Degler. Water Cooling Towers. *Power Eng.*, **54,** No. 5, 64 (1950).
18. W. F. Langelier. The Analytical Control of Anti-Corrosion Water Treatment. *J. Amer. Water Works Assoc.*, **28** (1936).
19. S. Powell, H. Bacon and J. Hill. Corrosion Prevention By Controlled Calcium Carbonate Scale. *Ind. & Eng. Chem.*, **37** (1945).
20. *Ibid* (3).
21. *Ibid* (3).
22. *Ibid* (3).
23. *Ibid* (6).
24. M. Darrin. Corrosion Inhibitors in Recirculating Water System. *Canadian Chem. & Proc. Ind.*, **33** (1949).
25. F. N. Speller. Corrosion Research. *Corrosion*, **1** (1945).
26. T. E. Larson. The Ideal Lime-Softened Water. *J. Amer. Water Works Assn.*, **43,** 649 (1951).
27. G. B. Hatch. Proceedings of the 11th Annual Water Conference, p. 15. Engineers Society of Western Pennsylvania, Pittsburgh, 1950.
28. *Ibid* (25).
29. W. G. Palmer. Corrosion Inhibitors for Steel. *J. of Iron & Steel Inst.*, **163** (1949); *Corrosion*, **7,** 10 (1951).
30. H. L. Kahler and C. George. Proceedings of the 11th Annual Water Conference, p. 1-9. Engineers Society of Western Penna., Pittsburgh, 1950.
31. *Ibid* (24).
32. *Ibid* (8).
33. Hammer, Powell and Coalbeck. Emulsions of Oil in Water as Corrosion Inhibitors. *J. of Iron & Steel Inst.*, Advanced Copy, Feb., 1945.

Supplementary Bibliography

S. B. Applebaum. Treatment of Cooling Water. *Combustion*, **22,** No. 5, 41 (1950).
D. R. Baker. Wood Deterioration in Cooling Towers. *Petro. Eng.*, **23,** No. 4, C-76, C-79 (1951).
C. L. Blohm and H. D. Frazier. Don't Let This Happen to Your Cooling Tower. *Chem. Eng.*, **57,** 140 (1950).
M. Brooke. Delignification of Redwood Cooling Towers. *Petro. Eng.*, **23,** No. 4, C-38 (1951).
M. Darrin. Chromate Corrosion Inhibitors. Water Conference, Engineering Society of Western Penna., **2,** 59 (1941).
U. R. Evans. Progress in the Corrosion Research Section at Cambridge University. *J. Iron and Steel Inst.*, **149,** 67 (1944).
U. R. Evans. Use of Soluble Inhibitors, Fundamental Principle. *Ind. and Eng. Chem.*, **37, 703-5,** 709 (1945).
E. W. Haering. Experimental Cooling Systems. *Ind. and Eng. Chem.*, **33,** 1360-5 (1941).
N. Hackerman and H. Schmidt. The Role of Adsorption from Solution in Corrosion Inhibitor Action. *Corrosion*, **5** (1945).
G. Hatch and O. Rice. Special Treatment of Water Systems. *Ind. and Eng. Chem.*, **37,** 710 (1945).
J. B. Kleber. Chemical Conditioning of Cooling Water. *Combustion*, **22,** No. 11, 45 (1951).
L. Lehrmann and H. Shuldener. The Role of Sodium Silicate in Inhibiting Corrosion by Film Formation on Water Piping. *J. Amer. Water Works Assoc.*, **43,** No. 3, 175 (1951).

J. Monteul. Anti-Corrosion Measures Necessary in Air-Conditioning Systems. *Refrig. Eng.*, **57**, 219 (1949).

C. P. Hoover. Practical Application of the Langelier Method. *J. Amer. Water Works Assoc.*, **30**, 1802 (1938).

E. Moore, L. Ruben, W. Sears. Report on the Experiences in the Use of Metaphosphate in Massachusetts. *J. New England Water Works Assoc.*, **64**, No. 4, 406 (1950).

W. J. Ryan. Preventing Corrosion in Air-Conditioning Systems. *Power*, **94**, No. 7, 84 (1949).

A. G. Sussex. Corrosion Inhibitors. *Metal Treatment and Drop Forgings*, **15**, 159 (1949).

DISCUSSION

Questions by H. F. Haase, Marquette University, Milwaukee, Wis.:

Vernon has used sodium benzoate as an inhibitor. Can you give data on this subject: 1. Is it correct that 1 percent sodium benzoate must be used? 2. Have other oxidizing agents such as permanganate been used instead of chlorine?

Reply by J. K. Rice:

Sodium benzoate has been used as an inhibitor in closed cooling systems at very much greater concentrations (1 percent) than can be considered for cooling tower operation.

I know of instances where permanganate is being used without notable success. The consumption is high and the end product is considerable sludge and deposits that are highly undesirable. As I indicated in the presentation, persulfate has been used successfully at least on a laboratory scale.

Question by Ivy M. Parker, Plantation Pipe Line Co., Bremen, Ga.:

Mr. Rice has given us a very good general picture of the treatment of recirculated water. He has recommended fairly heavy chlorine treatment. In view of present concern of many cooling tower operators with delignification of wood, I would like to know if Mr. Rice has specific information regarding the effect of various chlorine dosages on delignification of redwood.

Reply by J. K. Rice:

I have no specific information on the effect of various chlorine dosages. The residual chlorine levels suggested, however, have been employed in some few towers for several years without any noticeable effect. Alkaline chlorine solutions are a recognized pulping media. However, the concentrations employed in such processes are far in excess of those suggested in this paper. As you undoubtedly know, there are considerable differences of opinion at this time even as to the causes of wood deterioration in cooling towers (let alone the relative magnitude of the effect of each cause).

Question by Robert P. Lee, National Lead Co., Titanium Division, South Amboy, N. J.:

These questions are relative to fresh cooling waters used in evaporative, or spray type coolers where relatively low liquid velocities are obtained over the outer surfaces. 1. Do you have any experience which would afford a comparison of the inhibition efficacy of polyphosphates vs. chromates? 2. Is a chloride ion concentration of about 200 ppm too high to allow use of polyphosphates as an inhibitor?

Reply by J. K. Rice:

As a general rule, a high concentration of chromate, 200 ppm and up is a much better inhibitor than polyphosphate in any concentration and there are many instances to prove this both in laboratory and field. While the exact limit of chloride ion concentration above which no amount of polyphosphate will satisfactorily inhibit is not known, a concentration of 200 ppm is not at all excessive and certainly in itself should not preclude the use of polyphosphates.

Parts I and II

Corrosion Due to Tuberculation in Water Systems*

By J. L. MANSA* and WACLAW SZYBALSKI**

I. The Effect of Calgon on the Potential of Iron Electrodes in Differential Aeration Cells with Running Tap Water

Abstract

Influence of Calgon on potentials of electrodes in a differential aeration cell designed to approximate the conditions inside a pipe with running tap water is studied. Calgon decreases cathode potential by adsorption, thereby inhibiting oxygen access to the surface, while potential of the anode increases because Calgon interferes with anodic depletion of the oxygen. Corrosion current decreases as a result of these two effects and also because of the increasing internal resistance of the cell resulting from formation layers of Calgon and of corrosion products with low electrical conductivity. Differential layers of corrosion products in areas of greater water flow limit oxygen access and cause tuberculation and corrosion to cease.

Tests with zinc-iron electrodes in a differential aeration cell indicate corrosion of the zinc may follow the same pattern as that of iron. Calgon depresses the difference of potentials between anode and cathode as in the cell with iron electrodes and for the same reasons. After some weeks zinc becomes cathodic to iron in the cell where the zinc surface is exposed to aerated water and the iron electrode is in stagnant water. Potential of the zinc decreases as rate of flow of water decreases. Aeration cells with zinc, iron and copper electrodes are discussed.

IT IS THE PURPOSE of this work to show the manner in which Calgon interferes with the mechanism by which tuberculation occurs in water pipes. Preliminary experiments[1] showed minute concentrations of Calgon definitely prevented rusting of an iron surface exposed to laminar flow of water. With Calgon absent, well defined rust patterns were produced. When plates were exposed to tap water in which increasing amounts of Calgon were introduced formation of the "lines" of rust was gradually reduced, and at a concentration of about 20 ppm rust did not form at all.

Preliminary short term experiments showed only that when Calgon was introduced at the start of the experiments rust formation was prevented. Furthermore, Calgon added after rust had begun to form did not remove the rust and only high concentrations (over 100 ppm) seemed to inhibit further development of rust streaks. Iron surfaces exposed to water containing Calgon remained bright showing only some interference colors, indicating formation of a very thin protective layer.

These facts and indications in the literature[2] showed that the inhibitive effect of Calgon results from adsorption on the iron surface and that the material belongs to the class of adsorption inhibitors.[3]

However, the mechanism of the inhibitive effect of Calgon is interesting, especially its effect on the electrochemical potentials of electrodes in the differential aeration cell (DA cell) with running tap water.

There is a rather comprehensive literature[4] about measurements of the potentials of corroding metals and the influence of inhibitors on these potentials. Measurement of the potentials of corroding metals has been made mostly either in solutions with well defined, rather high concentrations of the respective metallic ions or in strong acid, alkaline or salt solutions. In many cases the potential measurements have been made with little regard to the influence of oxygen. Some potential measurements have been made also in natural waters, but either at rather short intervals or without taking into account the division of the metallic surface into anodic and cathodic zones.

Beginning with the experiments of Chyzewski and Evans,[5] many measurements have been made of the changes of potential resulting from inhibitors. Much literature in this field has been quoted by Shih-Jen Ch'iao and Mann.[6] But, as far as authors of this article know, no experiments have been made on the influence of the inhibitor on the potentials of the electrodes in a DA cell. Herzog and Chaudron[7] have studied the influence of some inhibitors, but only on the current generated by a DA cell.

DA cells have been studied principally in the form devised by Evans.*[8] The form of cell that occurs naturally (as tubercles in water pipes—Figure 1a) or its laboratory modification (Figure 1b) have apparently not been used for laboratory study before their use by Olsen and Szybalski.[9]

For the reasons given it is believed interesting to study the influence of inhibitors on potentials of anodes and cathodes of DA cells of a form normally met as tuberculation in water pipes. In these studies concentration of oxygen in the cathodic space will be constant, because the water is saturated with oxygen and flow is constant, while oxygen concentration on the anodic side will be controlled automatically by the corrosion process. In this way the influence of

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* Dr. F. L. LaQue kindly directed our attention to two early papers of Adie[21] and Viard,[22] describing the differential aeration effect.

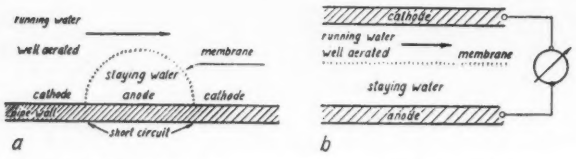
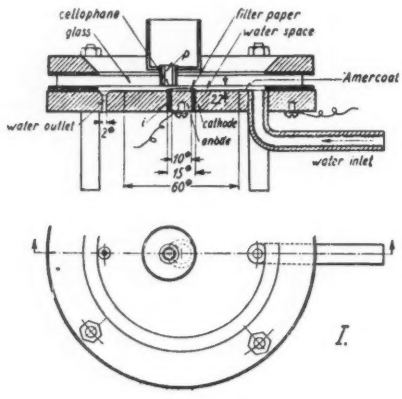
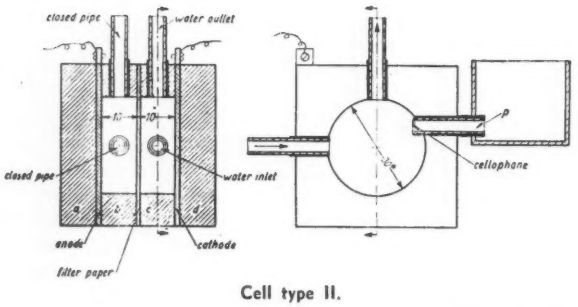


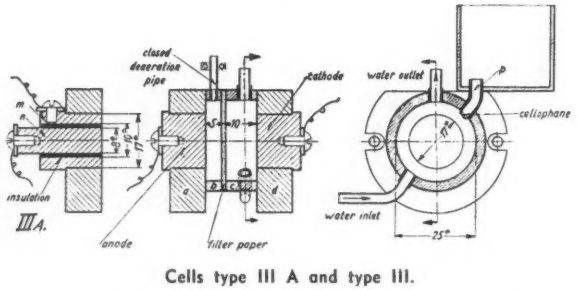
Figure 1—Schematic comparison of the conditions (a) during pitting with tubercle formation and (b) in laboratory model DA-cell (after Olsen and Szybalski).



Cell type I.



Cell type II.



Cells type III A and type III.

Figure 2—DA-cells for experiments with running tap water.

atmospheric oxygen is eliminated and the arrangement makes possible testing natural waters directly from municipal supplies. Furthermore temperature and pressure of the test water can be controlled.

In order to get well defined potential-time curves an automatic multipoint instrument was used and potentials of all cells were simultaneously tested against one standard calomel electrode while exposed to water from a 30-ton storage tank.

To determine the influence of Calgon the potentials of at least four cells was simultaneously registered, i.e., two with Calgon and two without. Reproducibility of the parallel experiment was within 1-5 mv. Equipment permitted extending the uninterrupted measurements on a particular cell to some months.

Experimental

Three types of DA cells were tested: Cell I with laminar water flow and Cells II and III with turbulent water flow (Figure 2). In all cells the metal surface was divided into two regions insulated from each other. Between the anode and cathode areas there was a filter paper membrane (Schleicher Schuell No. 589-2) to protect the anode from the direct water stream. In Cell I the membrane was attached with synthetic resin glue to the insulation *i* between the electrodes. In Cells II and III filter paper was fixed between parts b and c. In this way the cathodic surface of the metal was always washed violently with aerated water while in the anodic space the water was stagnant and the anode had, consequently, a limited supply of oxygen. Oxygen available to the anodic area was quickly used up by:

1. Oxidation of ferrous ions.
2. Depolarization of the micro-cathodic regions of the anode (due to the micro-cell structure of the anodic surface).
3. Direct oxidation of metallic iron.

For Cell I (dimensions shown in millimeters in Figure 2) a water flow of 300 ml/min was used, which gave a flow pattern over the main part of the metal surface (Reynolds No. — Re=100). The water flow was the same in Cells II and III, but because of the design the flow pattern was turbulent, which could be observed directly. Electrode material was S. M. steel with approximately 0.15-0.18 per cent C.

In order to get an even flow of water over the whole metal surface in Cell I only the central portion of the plate was used. The periphery was covered with a highly water-resistant coating of low electrical conductivity.* In order to get a consistently even flow it was necessary to change later in the experiment from Cell II to III because in the former in the corners of the aerated side between the plastic fabricated wall (*c*) and the metal plate, the water moved very slowly in comparison to that at the central part of the plate. In Cell III the surface of the cathode did not extend to these dead corners.

Another difference between Cells II and III was that the central part (b, c) or Cell III consisted of a plexiglas tube permitting the experimenter to observe changes in the cell during the experiment. The distance between the electrodes was reduced in Cell III in order to get lower internal resistance and the symmetry of the cell shape was sacrificed. In all cells metal surfaces (excluding the anodic and cathodic areas) which might contact water and could influence the potentials measured, were coated.* The electrolytic connection between running water and the standard calomel electrode (saturated KCl solution) was made by a saturated KCl solution, the water and solution being separated by a thick cellophane

* Amercote No. 23.

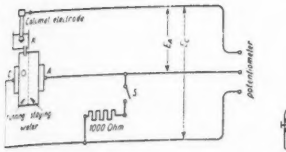


Figure 3—The diagram of electric connections for automatic potential registration in a DA-cell.

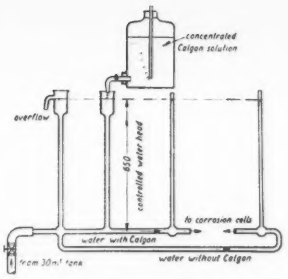


Figure 4—The diagram of water-connection arrangement for experiments with DA-cells.

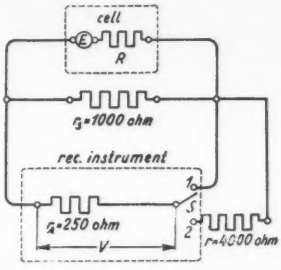


Figure 5—The diagram of electric connections for automatic measurement of the corrosion current and internal DC-resistance in a DA-cell.

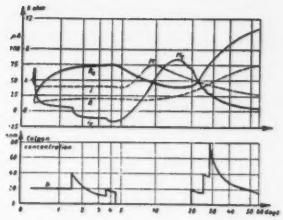


Figure 6—Time-corrosion current (i,i_c), time-internal DC-resistance (R, R_c) and time-Calgon concentration (b) curves for DA-cells type I with (i_c R_c) and without (i, R) addition of Calgon. Rate of water flow 300 ml/min.

membrane. Air from the glass pipe p had been sucked out with a thin plastic pipe so as not to damage the membrane. The insulation *i* (Figure 2 I) and the parts *a*, *b*, *c*, *d* (Figure 2 II) *a*, *d* (Figure 2 III) consisted of linen-Bakelite laminate.

First experiments were made by continuously measuring currents between cathode and anode and only occasionally by measurement against the reference electrode. But it was found soon it would be necessary and more convenient to register the potentials automatically, so a multiple potentiometric recorder* was used with the range scale extended to 1000 mv and registration frequency six times a minute. Figure 3 shows connection diagram. Potentials of the anode and cathode could be measured either when they were connected through a 1000-ohm resistance or when disconnected. If several cells were used, connections between the calomel electrode and the respective cell cups (K—Figure 3) were made with saturated KCl-agar bridges, rather thick and as short as possible because the resistance of the potentiometric circuit could not exceed 10,000 ohms. This limitation of the potentiometer was inconvenient. The diagram of the arrangement of the water connections and the feeding of Calgon is given in Figure 4.

Analysis of water used is given in Table I.

Experimental Results

1. *The Measurement of the Corrosion Current and Internal Resistance of the DA cell.*

Measurement was made with Cell I using the "Electroflo" recording instrument. The scheme of connections is shown in Figure 5. By reading v_1 and v_2 (switch s in position 1 or 2 respectively) the internal resistance of the cell could be calculated. The cathode and anode were continuously connected through a 1000-ohm resistance. The calculated internal DC resistance of the cell at the beginning of the experiments was of the order of 1000 ohms. Curves R and R_c (Figure 6) show changes with time of the cells' internal resistance. Curves i and i_c show the corrosion current. It is seen that if the Calgon is added at the very beginning of the experiment when the iron surface is bright, it has a very strong influence on the increase of the internal resistance of the cell and on the decrease of the corrosion current. It is obvious the decrease in the corrosion current cannot be explained only on the basis of the increase of the resistance. The current not only decreases but it also changes direction. That means Calgon must change the potentials of the electrodes. The peaks M and M_c also indicate some changes in potential. For this reason in further experiments potentials only are measured, trying on this basis to explain the mechanism of Calgon's action.

$$R = \frac{v_2 r - (v_1 - v_2)\, r_A}{(v_1 - v_2)\left(\frac{r_A}{r_s} + 1\right) - v_2 \frac{r}{r_s}}$$

Curve i, at its beginning, shows very characteristic sudden drops at the points of increased Calgon addition. Curve R_c shows continuous changes. After discontinuing the addition of Calgon on the fifth day it is seen that its inhibitive effect is fully reversible.

The next addition of Calgon to a 20-day-old cell shows the same changes as were registered in the beginning but much slower and smaller (the apparently steep slope of i_c and R_c curves is a consequence of the logarithmic time scale). Reversal of the corrosion current was not observed in old cells. Curves R and i show also that without the addition of Calgon there is an increase of resistance and a decrease of the corrosion current in the cell probably as the result of the formation of compact layers on the cathode as has been shown by the capacity and the AC and DC resistance measurement (Olsen and Szybalski[9]).

After finishing the experiment the cell was opened,

* Multipoint Potentiometric Recorder, Leeds & Northrup "Speedomax."

TABLE I

Saturation index (pH — pH$_S$)	— 0.1 — + 0.1	pH	7.5	SiO_2	15 — 17 ppm
Total Hardness	18.3 — 18.8° H	Cl^-	81 — 93 ppm	Fe^{++}	0.01 — 0.03 ppm
Permanent Hardness	1.2 — 2.0° H	SO_4^{--}	71 — 72 ppm		
Dissolved Solids	560 — 571 ppm				

Water was Air-Saturated at Atmospheric Pressure (8° C).

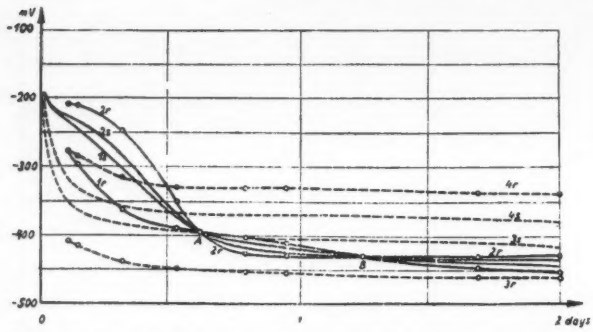


Figure 7—Time-potential curves for the aerated (2, 4) and non-aerated (1, 3) electrodes of DA-cells type I with (1, 2) and without (3, 4) addition of Calgon. Electrodes connected through a 1,000-ohm resistance (s) or disconnected (r). Rate of water flow 300 ml/min.

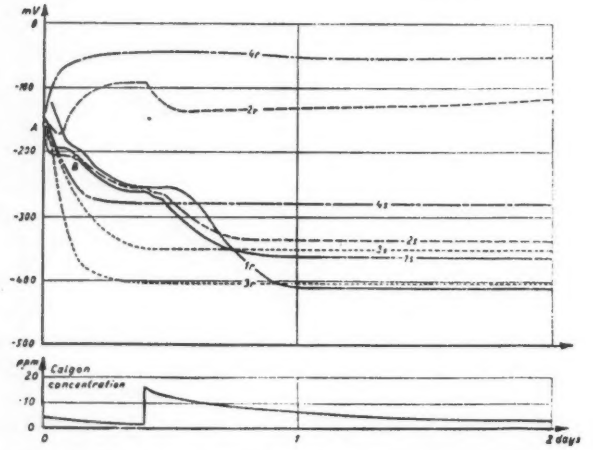


Figure 8—Time-potential and time-Calgon concentration curves for DA-cells type III A with (1, 2) and without (3, 4) addition of Calgon. Aerated (2, 4) and unaerated (1, 3) electrodes connected through a 1,000-ohm resistance (s) or disconnected (r). Rate of water flow 300 ml/min.

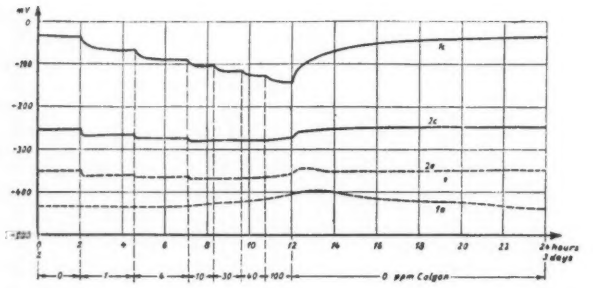


Figure 9—The effect of various Calgon concentrations on the potentials of an aerated (c) and non-aerated (a) electrode of a two-day-old DA-cell. Electrodes connected through a 1,000-ohm resistance (2) or disconnected (1). Rate of water flow 300 ml/min.

the filter paper membrane removed and the anodic and cathodic surfaces examined. The anodic space under the membrane was filled with rust which could easily be washed off with a water stream. Underneath the iron surface appeared evenly corroded and of a dull metallic lustre. The cathodic surface outside the anode was covered almost completely with a thin, strongly adherent layer, but in some places elevated rust paths appeared, which it was possible to remove by washing and gently brushing. This uncovered an underlying iron surface similar to that under the

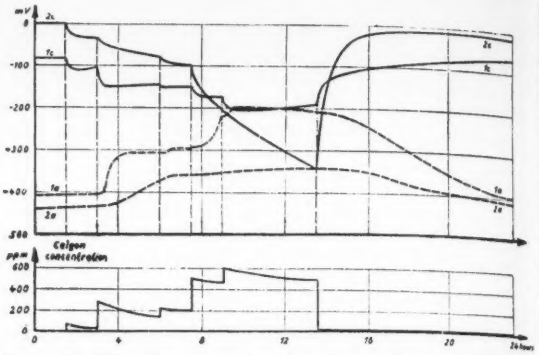


Figure 10—The effect of various Calgon concentrations on the true potentials of an aerated (c) and a non-aerated (a) electrode in a one-day (1) and a six-day-old (2) DA-cell. The electrodes disconnected eight hours before each start of the addition of Calgon. Rate of water flow 300 ml/min.

filter-paper membrane. These rust paths appeared in places where there was a slower stream of water and consequently smaller aeration than in the neighboring areas. This tubercle formation on the cathodic surface certainly interfered with the reproducibility of our experiments, but with this shape of cell and with laminar water flow it was impracticable to get a uniform water flow over the whole surface and, consequently, even aeration. For this reason, and because when using a slow stream of water potential differences are small between the anode and cathode, it was decided to change over to cells of another shape using turbulent water flow.

2. *The Measurement of Potentials*

In measuring potentials of the electrodes there were two alternatives:

1) The anode and cathode short-circuited through a low resistance. The situation would then be just the same as in a natural "tubercle" but it would be possible independently to measure true potentials of the cathode and anode.

2) The anode and cathode disconnected. It was possible then to measure the true potentials independently, but the conditions in such a cell are different from those in a real tubercle.

So a combination of both was selected. During most of the time of the experiment the electrodes were connected through a 1000-ohm resistance and only from time to time was the circuit opened so that true potentials against the calomel electrode were registered.

Diagram (Figure 7) shows the potential-time curves of two cells of type I with a water flow of 300 ml/min. Electrodes of both cells were connected through a 1000-ohm resistance (switch *S* closed—Figure 3). Curves 3s and 4s show the potential of iron in contact with water falling from about —200 mv to —370 mv for an aerated and to—405 mv for an unaerated electrode (normal hydrogen-electrode scale) in the course of 24 hours. The decrease after that time is much slower. Potential difference between the anode and cathode is rather pronounced from the first hours of experiment. From curves 1s, 2s (water with 10 ppm. Calgon-product of Albright and Wilson, Bir-

mingham) it is seen that the potential first falls slowly, then quickens to finally reach a level more negative than curves 3s, 4s. Moreover in the latter half of the first day the potential of the aerated electrode was more negative than of the unaerated one. That is in good agreement with the reversal of the corrosion current on the diagram in Figure 6. In experiments with higher Calgon concentrations it was possible to get reversed and still greater potential differences and hold them for many days.

Curves 1r, 2r, 3r, 4r show the real potentials of the electrodes which were registered by means of a potentiometer when opening the switch *S* (Figure 3) for a short time at the points marked on the diagram (Figure 7). The features shown by curves 1s, 2s, 3s, 4s are still more pronounced.

The diagram in Figure 8 shows the continuous time-potential curves for two cells of type III with double electrodes (Figure 2, III A). Electrodes *m* were connected through a 1000-ohm resistance (curves 1s and 2s with Calgon and 3s and 4s without). Internal electrodes *n* were not connected so that they show their true potentials (curves 1r, 2r with Calgon; 3r, 4r without). It can be seen that a cell of type III shows much greater potential difference and a more noble cathode due to the turbulent flow of water and consequently to the greater aeration of the cathodic surface. At this low Calgon concentration it was possible to find the potential difference reversed during the first hour of the experiment only. The potential difference for a cell run with Calgon-treated water is smaller than for a cell without Calgon. Adding increasing quantities of Calgon causes a very distinct decrease of the cathode potential (2r). Reducing the quantity of Calgon added results in slow restoration of the more noble potential. The influence on the anode is difficult to discuss because the potentials of the electrodes have not yet reached a steady state.

Influence of Calgon on two-day-old cells, where the cathode and anode have reached fairly stable balanced potentials, is shown on the diagram Figure 9. Curves 2a and 2c show the potentials of the anode and cathode connected through a 1000-ohm resistance of a cell of type III. The upper curves 1a and 1c show true potentials of a parallel cell where electrodes have been disconnected eight hours before Calgon was added. Every increase in the quantity of Calgon causes a decrease of the cathode potential, but low concentrations of Calgon show a relatively greater effect. The effect on the anode is slower and changes of potential are in the noble direction. That is the reason why at concentrations higher than 40 ppm. the curves 2a and 2c not only cease to move in the negative direction but also change to the noble one.

The diagram in Figure 10 shows the influence of the age of the cell on the potential-time curves. On both electrodes the Calgon-effected changes are slower with increasing age of the cell. On the anode, moreover, the changes are smaller, but not on the cathode.

The diagram in Figure 11 shows the influence of changes of water-flow velocity. When the flow of water through the anodic space (the deaeration pipe under the filter-paper membrane (Figure 2, III) is

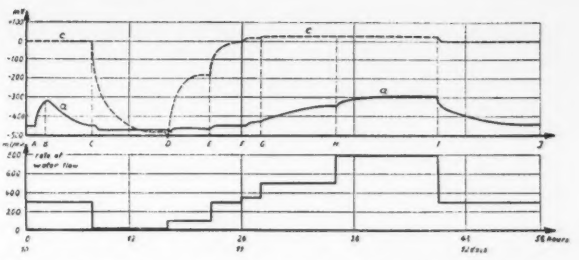


Figure 11—The effect of the rate of water flow on the potentials of an aerated (dotted line) and a non-aerated (solid line) electrode in a six-day-old cell. Explanations in text.

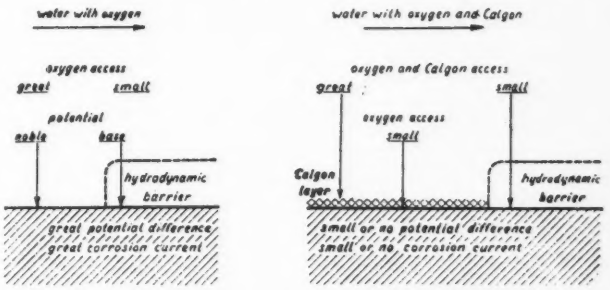


Figure 12—Diagram of the influence of Calgon on the corrosion due to the action of DA-cells.

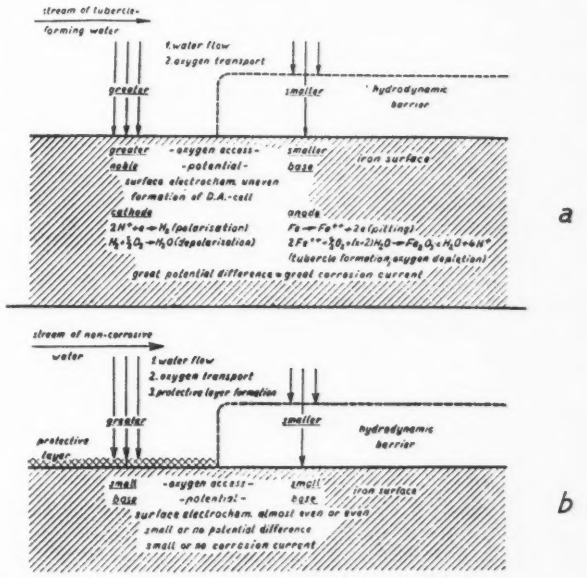


Figure 13—Diagram of the influence of tubercle-forming (2) and non-corrosive (b) waters on the corrosion due to the action of DA-cells.

increased, (rate of water flow through it = 2 ml/min.) the potential of the anode is increased (A—B). Interruption of this percolation (the deaeration pipe closed) restores the original state but more slowly (B—C). Interruption of the whole water flow through the cell causes the potentials of the electrodes to be equalized (C—D). Returning to the previous velocity of the water flow ennobles the potential of the cathode to the former value (D—E—F). An increased water flow first has a pronounced effect on the increased cathodic potential and almost none on the

anodic potential (D—E—F), but further increase of the water velocity brings the cathodic potential to a constant value and only causes a further increase of the anodic potential (F—G—H). A reduction of the water flow to 300 ml/min. restores the first observed potentials (I—J).

Conclusions

Most striking feature observed in all experiments was the great range of different potentials shown by iron. Ennoblement of the iron potential is referred to by the term passivation. The nature of passivity is still an object of controversy in the literature (e.g., Evans,[3] Uhlig[10]), but for purposes of these tests it is regarded as a result of some factor which impedes the passage of metal ions from the surface of the crystal lattice to the water solution. Oxygen adsorbed or chemically bound in a reversible manner on the metal surface stabilizes its lattice and diminishes the tendency of the metal to pass into solution, which means that the potential of the metal becomes more noble. The passivity and ennoblement of the iron potential* depend on the saturation of the metal surface with oxygen, but because the adsorption process is reversible and because the oxygen is consumed constantly in the oxidation of hydrogen and ferro-ions, a constant supply of oxygen to the metal surface is necessary. Covering of the metal surface with a porous layer impedes oxygen diffusion to the true iron surface. Saturation of the metal surface with oxygen decreases and consequently the potential is shifted in the base direction. This porous layer could be of various kinds. It could be deposits of rust or of a microbiological character or any other hydrodynamic barrier which diminishes the water velocity in an area and thereby decreases the oxygen transport to the iron surface. But also the adsorption layer of large molecules of Calgon or its complexes with other substances found in natural waters, seems to have the same depressing effect on the potential of iron because oxygen access is hindered. But there is a fundamental difference between the action of Calgon-layers and other hydrodynamic barriers. The situation is shown on the following diagram (Figure 12). In cathodic areas where water carrying oxygen and Calgon has easy access to the iron surface, the Calgon adsorption layers develop rapidly and consequently do not permit oxygen to diffuse to the true metal surface. In this way instead of getting an easier oxygen access to the true iron surface in places of greater water flow the oxygen access becomes more difficult and the electro-chemical potential decreases. At small concentrations of Calgon its transport to surfaces covered by hydrodynamic barriers will be very small so no great changes can be expected there. Consequently on a fresh iron surface, after the addition of Calgon, there will be no great changes in the potential of the anodic areas (leaving out of account the secondary influence of Calgon due to the interference of Calgon with the reaction of the oxygen depletion) and the higher cathodic potential will decrease with a resulting decrease of potential difference and corrosion current.

This reduced corrosion current causes a decrease of production of ferro-ions at the anode, permitting greater oxygen diffusion to the anodic surface with a resulting decrease of potential difference and corrosion current. That induces a further reduction of the production of ferro-ions on the anode, etc.

This picture of the influence of Calgon is very clear in the case of rather good differentiation of the iron surface into regions with an exposed clean metal surface and regions covered by hydrodynamic barriers. Covering of the metal surface with protective layers or a rather strong development of tubercles changes the speed and effectivity of the action of Calgon.

The reported peptization power of Calgon[13] causing the solution and removal of the tubercles must also be taken into consideration, because it means the removal of the well developed hydrodynamic barriers and consequent equalization of the aeration and the potentials of the metal surface.

This explanation of the cathodic Calgon action can be extended to explain the tuberculation faculty of natural waters. It is certain that aerated water running over an iron surface will always, in the beginning, cause formation of differential aeration cells, because the velocity of the water will change from point to point owing to the hydrodynamic properties of the surface. In this way in the places where there is a higher rate of water flow will have better access to oxygen and a more noble potential. Non-corrosive waters (Figure 13b) are able to quickly form impervious layers in areas where water velocity and consequently the aeration are greater, which diminishes the oxygen access and turns the potential in the base direction in the same places. In places where water is exchanged rapidly the non-corrosive water must have ability to form strong protective layers so oxygen access to the true metal surface will be more difficult than in places with lower water flow. That will cause equalization or even reversal of the difference of potentials between more and less washed areas, and consequently there will be no tuberculation. This cathodic formation of a protective layer must be quick, before (owing to the primary differential aeration effect) well developed rust tubercles develop in the anodic areas with a consequent heavy decrease of potential in comparison with the rather small primary potential differences due to metal surface irregularities.

Tubercle-forming water (Figure 13a) lacks ability to form protective layers quickly in areas of primary better oxygen access. That means that in every anodic area of the primary DA-cells resulting from uneven water flow, there is, in a borderline case, formation of tubercles. This case is not very dangerous, because the ratio of the cathodic to the anodic areas is then rather high and because there is a possibility anodic rust deposits, always extending beyond the anodic surfaces, will all join together, causing an even, minimum oxygen access to the whole surface. More dangerous is the case when the water has a

* The potential difference between two identical electrodes immersed, one in stagnant and the other in a running "oxygen-free" water solution, has been called Motor-Electric Potential,[11] but there are various opinions in the literature as to the nature of this effect.[12] Many authorities believe it could be referred to the action of the omnipresent oxygen. Apart from the nature of the motor-electric potential, its reported values are negligible in comparison with the fluctuation of potential observed in these experiments and caused by the differential aeration effect.

limited ability to form protective layers. In this case only a few primarily stronger DA-cells will develop tubercles on the anodic surfaces, but because of the high ratio of the cathodic to the anodic surface the pitting can be rather serious.

Biological deposits are especially active in causing tuberculation either by interference with the cathodic formation of the protective layers or by very quick establishment of highly anaerobic conditions in primarily anodic areas with such a rapid decrease of potential the slower cathodic decrease due to formation of a protective layer cannot equalize the potentials and stop the tubercle formation. The literature often shows that together with tuberculation a growth of iron bacteria has been found.[9,14,15]

The non-corrosive water must show not only the ability to form protective layers, but this ability must also be 1) quick and energetic 2) differential—i.e., stronger where there is a higher rate of water flow and primary oxygen access and weaker in the other places.

The nature of the protective layers built by natural waters and acting in the same way as Calgon will not be discussed here.

On this theoretical basis some aspects of the experiments described above can be discussed.

Decrease of the cathodic potential caused by the increase of the Calgon concentration can be seen in Figures 9 and 10, curves 1c and 2c. It is shown that small additions of Calgon to a one-day-old cell give more rapid changes, which can be explained as resulting from easier Calgon access to the fresh iron surface. A heavy and a long-term addition of Calgon shows a greater effect on the older cell. It seems that the joint effect of the cathodic covering of the surface by Calgon and by natural protective layers gives a better protection against oxygen access, but a somewhat longer time is necessary for the development of such layers.

At the anode a higher Calgon concentration has an influence on the potential opposite to the influence on the cathode. This influence is more pronounced in young than in old cells, because in old cells the diffusion of Calgon through the membrane toward the anodic surface is strongly impeded by the development of rust in the whole anodic space. This ennoblement of the anode potential by the addition of Calgon may be explained in two ways:

1) Calgon has the same effect on the potential as oxygen.
2) Calgon interferes with the process of consuming the oxygen for the anodic oxidation processes.

Explanation 1) is not very probable, because of the substantially different Calgon action on the cathode. Explanation 2) sounds reasonable because if the consumption of oxygen in the anodic space slows down or stops, then the difference in the oxygen concentrations in the anodic and the cathodic space will be slowly equalized with a consequent increase of the anodic potential. The oxygen diffusing to the anodic space is mostly used for i) oxidation of ferro to ferric ions, ii) oxidation of hydrogen on the cathodic surfaces of micro-corrosion cells due to the uneven structure of the anodic metal surface and iii) direct oxidation of metallic iron. It has not been determined if the auto-oxidation of ferro ions is retarded by the presence of Calgon. Nor can it be said if Calgon interfers with the two other reactions.

The curve i_c on the diagram in Figure 6 shows the corrosion current when Calgon is added. The decrease of the current is the result of the decrease of the potential difference and the increase of the internal resistance of the cell due to the formation of the Calgon layer on the metal surface (curve R_c). At the outset of the experiment it was possible to get a reversal of the current also in the case of a low Calgon concentration, because the highly anaerobic conditions in the anodic space have not yet been established. It is obvious that this reversal of the current is due to the reversal of potentials, which could be seen in Figures 7 and 8 between points A and B. If the hydrodynamic barrier between the anodic and cathodic surfaces is less developed, and there is a smaller water stream (cell I, Figure 2) then it is easier to bring about the reversal of potentials by a smaller addition of Calgon than in the better developed DA-cell (Cell III, Figure 3).

Diagram in Figure 11 shows the great influence changes of water flow (aeration) have on the potential of a DA-cell. It is seen that ennoblement of the iron potential due to the oxygen content of water is fully reversible. After the interruption of the water flow, when oxygen will be used up in oxidation processes, there is an almost equally base potential of both electrodes (C—D). First the increase (D—E—F) and afterwards the decrease (F—G—H—I) of the potential difference by the increase of water flow are in good agreement with the phenomenon often reported in the literature of an increase of the corrosion rate and tuberculation with increasing rates of flow to some critical value, after which the corrosion decreases (for instance, Hayn and Bauer,[16] Friend,[17] Pallo[18]—the apparently different results of Speller and Kendall[19] are discussed by Russell, Chapell and White[20]).

Summary

Influence of Calgon on the potentials of the electrodes in a DA-cell with running tap water has been studied. Calgon decreases the potential of the cathode by the formation of an adsorption layer on its surface, which inhibits the oxygen access to the iron surface with a consequent decrease of its passivating action. The potential of the anode rises because Calgon interferes with the anodic depletion of oxygen. Both these effects cause the decrease of the potential difference and corrosion current. The decrease of the corrosion current is also caused by the increase of the internal resistance of the cell resulting from formation of protective layers of low electrical conductivity. The peptization power of Calgon also must be taken into consideration.

An attempt at a general theory of tubercle-forming and non-corrosive waters is based on the property of non-corrosive waters of the differential formation of protective layers in the areas of greater water flow, which decreases the oxygen access in these primary

cathodic zones, equalizes the potentials and causes the corrosion and tuberculation to cease. Some general aspects of the DA-cell are discussed and the phenomenon of critical corrosion rate with a successive increase of water flow is explained.

References

1. J. L. Mansa *Acta Chem. Scand,* **4,** 1247 (1950).
2. G. B. Hatch and O. Rice *Ind. Eng. Chem.,* **37,** 710, 752 (1945); Committee Report, *J. Amer. Wat. Works Assoc.,* **34** 1807 (1942).
3. U. R. Evans Metallic Corrosion, Passivity and Protection. London (1946).
4. B. Boonstra *Korr. Met.,* **17,** 21 (1941). L. H. Callendar *Proc. Roy. Soc.* (a) **115,** 349 (1927). O. Gatty and E. C. R. Spooner. The Electrode Potential Behaviour of Corroding Metals in Aqueous Solution. Oxford (1938). P. T. Gilber. *J. Scient. Instr.,* **22,** 235 (1945). L. Guitton. Methodes Potentio-Metrique a l'etude de la Corrosion des Alliages Ferreux. Paris (1936). W. J. Muller. *Korr. Met,* **13,** 144 (1937).
5. E. Chyzewski and U. R. Evans. *Trans. Electrochem. Soc.,* **76,** 215 (1939).
6. Ch'iao Shih-Jen and C. A. Mann. *Ind. Eng. Chem.,* **39,** 910 (1947).
7. E. Herzog and G. Chaudron. *Comptes rend.,* **192,** 837 (1931).
8. U. R. Evans. *J. Inst. Met.,* **30,** 267 (1923).
9. E. Olsen and W. Szybalski. *Acta Chem. Scand.* **3,** 1106 (1949). *Corrosion,* **6,** 405-414 (1950).
10. H. H. Uhlig. Corrosion Handbook. New York (1948).
11. E. Newbery and G. A. Smith. *Trans. Electrochem. Soc.,* **73,** 261 (1938).
12. J. F. Chittum and H. Hunt. *Ibid.,* **71,** 207 (1937); C. G. Fink and H. B. Linford. *Ibid.* **72,** 461 (1937).
13. L. Newell. *Water & Sew. Work.,* **93,** 71 (1946).
14. E. W. Barbee. *J. Amer. Water Works Assoc.,* **39,** 220 (1947).
15. L. Minder. *Schweiz. Ver. Gas. Wasserf. Monatsbull.,* **16,** 102 (1936); H. Mohler and J. Hartnagel, *Ibid.,* **19,** 121, 147 (1939).
16. E. Hayn and O. Bauer. *Mitt. Kgl. Mat. Pruf. Amt.,* **28,** 62 (1910).
17. J. A. N. Friend. *J. Chem. Soc.,* London, **119,** 932 (1921).
18. P. E. Pallo. *J. Amer. Water Works Assoc.,* **38,** 499 (1946).
19. F. N. Speller and V. V. Kendall. *Ind. Eng. Chem.,* **15,** 134 (1933).
20. R. P. Russell, E. L. Chapell and A. White. *Ibid.,* **19,** 65 (1927).
21. R. Adie. *Phil. Mag.,* **31,** 350 (1847).
22. M. Viard. *Phil. Mag. S.,* **4,** 6, 241 (1853).

II. The Effect of Calgon on the Potential of Zinc and Copper Electrodes in Differential Aeration Cells with Running Tap Water

In the previous paper[1] time-potential curves of iron electrodes in differential aeration cells (DA-cells) with running tap water were studied and a general theory for the explanation of the tuberculation properties of corrosive and non-corrosive waters was advanced.

In domestic water supply systems galvanized, i.e., zinc coated, pipes are often used instead of black iron pipes. Therefore it was interesting to study the electrochemical behavior of zinc and zinc coatings in the zinc-zinc and zinc-iron DA-cells.

The construction of cells, electric and other equipment, has been described in the previous paper.[1] In the experiments described below similar cells (type III) were used except that the iron electrodes were replaced by zinc, zinc-coated or copper electrodes of the same construction. All values of potentials are given in millivolts in the normal hydrogen-electrode scale.

Figure 1—Time-potential curves for the aerated (1, 3) and non-aerated (2, 4) zinc electrodes of DA-cell type III. Electrodes connected (3, 4) through a 1,000-ohm resistance or disconnected (1, 2). Rate of water flow 300 ml/min.

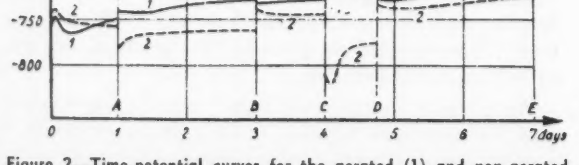


Figure 2—Time-potential curves for the aerated (1) and non-aerated (2) zinc-coated (galvanized) electrodes of a DA-cell. Electrodes connected (0—A, B—C, D—E) through a 1,000-ohm resistance or disconnected (A—B, C—D). Rate of water flow 300 ml/min.

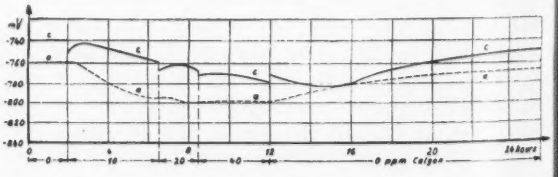


Figure 3—The effect of various Calgon concentrations on the true potentials of the aerated (c) and the non-aerated (a) zinc-coated electrode, disconnected eight hours before the start of the experiment. DA-cell type III, one day old. Rate of water flow 300 ml/min.

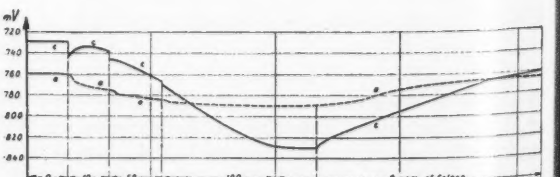


Figure 4—The effect of various Calgon concentrations on the true potentials of the aerated (c) and the non-aerated (a) zinc electrode disconnected eight hours before the start of the experiment. DA-cell type III, three days old. Rate of water flow 300 ml/min.

Zinc-Zinc DA-Cells

Curves 3 and 4 (Figure 1) show the potentials of aerated and unaerated zinc-electrodes connected through a 1000-ohm resistance and measured against a calomel reference electrode (saturated KCl). Only in the beginning of the experiment does the aerated electrode show a slightly more base potential than the unaerated one. After about nine hours the potentials change. The potential difference slightly increases during the first days of the experiment. Curves 1 and 2 show the true potentials of the same electrodes disconnected.

Figure 2 shows the potentials of the galvanized iron electrodes. In the intervals OA, BC, DE the electrodes are connected through a 1000-ohm resistance. In the intervals AB, CD electrodes are disconnected. It is seen that after every disconnection the potential difference between the electrodes decreases. After the connection the EMF of the DA-cell rises slowly.

The diagrams in Figures 3 and 4 show the effect of the addition of Calgon on the potentials of the disconnected electrodes of the zinc-zinc DA-cell. We see that the addition of Calgon diminishes the potentials, both the cathode and anode. The effect on the easier accessible cathode is the greater one. Addition of sufficient Calgon may change the direction of the potential difference.

Conclusions: The DA-cell with zinc electrodes shows a qualitative behavior similar to that of a cell with iron electrodes. Quantitative results, however, vary more: Potentials in the beginning of the experiments are much more base (about—750mv) but show the characteristic continuous increase especially with galvanized electrodes. The potential difference in the beginning of approximately zero or slightly negative increases much slower and remains lower than with an iron cell. That seems to indicate a much smaller oxygen concentration gradient between the cathodic and anodic surfaces which could be accounted for by the lack of the anodic secondary reaction consuming oxygen as in the case of the oxidation of ferro to ferric ions.

The quick decrease of the potential difference after disconnecting the electrodes (Figure 2; C—D) indicates that the reactions going on at the electrodes during the passage of the current play an important role in establishing the potentials. The continuous renewal of the anodic zinc surface due to the dissolution of the anode could be the cause of the decrease of its potential owing to the diminishing of the chemo-adsorbtion of oxygen.

The potential-depressing effect of Calgon, both on the cathode and anode, could be explained on the basis of the film-forming property of Calgon and consequent decrease of the oxygen transport to the true metal surface. In the zinc cell the effect of Calgon on both electrodes has the same direction (Figures 3 and 4) because the secondary reaction of the anodic oxidation is not found here as in the case of iron, where the interference of Calgon with this reaction causes an increase of anode potential.

Zinc-Iron DA-Cells

It is a common belief that zinc is always electronegative to iron in a natural water environment. This belief is based on the normal potential series of metals and on short experimental observations of iron-zinc couples. But pitting with overlaying tubercles and rusting of galvanized iron pipes indicate possible changes in potential, which has been emphasized by Davis,[2] Haase[3] and others. Schikorr[4] has been able to show a cathodic behavior of zinc versus iron in hot tap water after some hours of measurement. Roters and Eisenstecken[5] show such a change of the current direction in zinc-iron couples in cold tap water after about two months. Gilbert,[7] Hoxeng and Prutton[8] have also experimentally shown reversals of the zinc-iron potential in hot, respectively in cold water.

In preceding experiments with iron and zinc DA-cells it is seen that the potentials of both metals can vary markedly, but overlapping of the zinc and iron time-potential curves has not been observed. But as the measurement with zinc was a rather short one and the potentials still showed a tendency to increase (Figures 1 and 2), a cell was built with an aerated zinc electrode and a non-aerated iron electrode. The diagram in Figure 5 shows that after 8½ days the aerated zinc electrode, violently washed by running water, has become cathodic to the iron electrode in

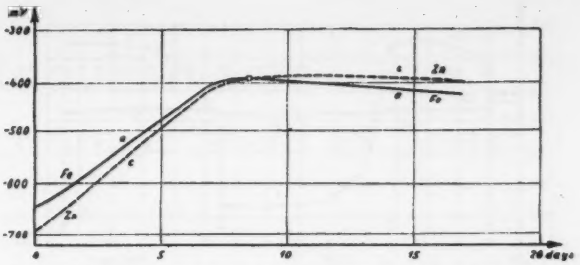


Figure 5—Time-potential curves for the aerated (c) zinc electrode and the non-aerated (a) iron electrode of a DA-cell. Electrodes connected through a 1,000-ohm resistance. Iron electrode 25 days old (stagnant water); zinc electrode 15 days old (running aerated water). Rate of water flow 300 ml/min.

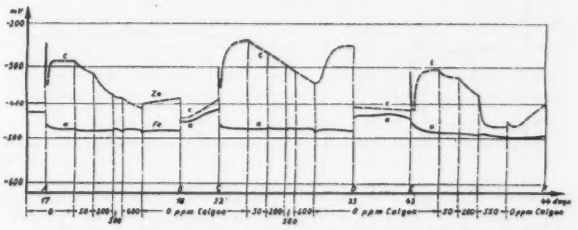


Figure 6—The effect of various concentrations of Calgon on the potentials of the aerated (c) zinc electrode and the non-aerated (a) iron electrode of a 17 days old DA-cell. Electrodes connected through a 1,000-ohm resistance (O—A, B—C, D—E) or disconnected (A—B, C—D, E—F). Rate of water flow 300 ml/min.

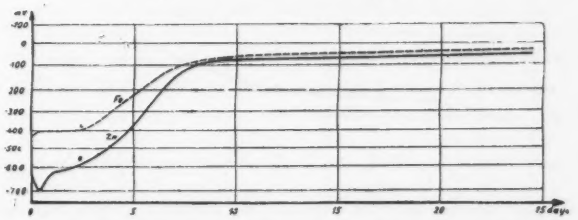


Figure 7—Time-potential curves for the aerated (c) iron electrode and the non-aerated (a) zinc electrode of a DA-cell. Electrodes connected through a 1,000-ohm resistance. Rate of water flow 300 ml/min.

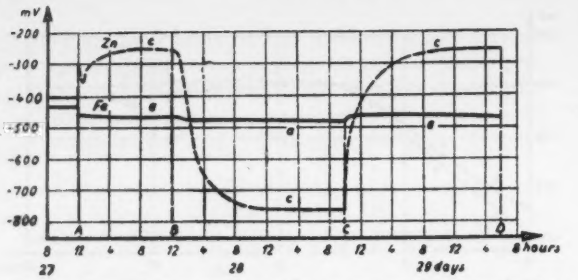


Figure 8—The effect of the rate of water flow on the potentials of an aerated (c) iron electrode of the 27-day-old DA-cell. Electrodes connected through a 1,000-ohm resistance (O—A) or disconnected (A—D). Rate of water flow 300 ml/min (O—B, C—D) or O ml/min (B—C).

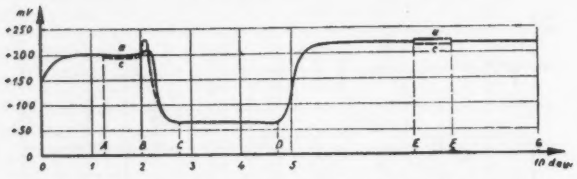


Figure 9—Time-potential curves for the aerated (c) and the non-aerated (a) copper electrodes of a DA-cell. Electrodes connected through a 1,000-ohm resistance (O—A, C—E, F—G) or disconnected (A—C, E—F). Rate of water flow 300 ml/min (O—B, D—G) or O ml/min (B—D).

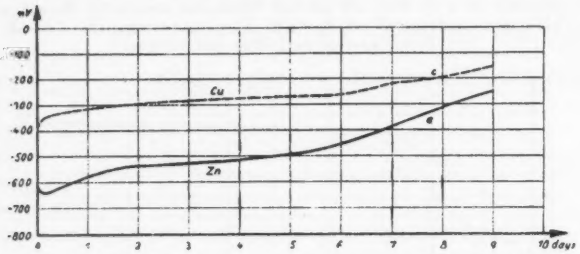


Figure 10—Time-potential curves for the aerated (c) copper electrode and the non-aerated (a) zinc electrode of a DA-cell. Electrodes connected through a 1,000-ohm resistance. Rate of water flow 300 ml/min.

stagnant water. After 17 days the cell connected through a 1000-ohm resistance shows EMF equal to 30 mv. In the disconnected 18-day-old cell zinc shows a potential as high as —300 mv and iron —490 mv, i.e. the potential difference was 190 mv. After 23 days a potential difference of 230 mv was observed.

These facts seem to be adequate explanation for the pitting and tuberculation in galvanized pipes where we have zinc-coated cathodic surfaces against the iron surface at the bottom of pits.

The addition of Calgon (Figure 6) causes a marked decrease of cathodic potential. But almost no changes are seen in the potential of the anode, which may be explained by the age of iron electrode ($18 + 25 = 43$ days) and a consequently large accumulation of rust in the anodic space that inhibits the diffusion of Calgon into it.

The cathodic behaviour of zinc against iron seems to be reversible, and after the discontinuation of the water flow across the zinc surface (B, Figure 8) the potential of zinc falls to a value lower than the value of the potential of the iron electrode. Restoration of the flow of water (C) brings the zinc potential to the former noble value.

For the sake of comparison the time-potential curves have been measured for cells with the aerated iron cathode and the zinc anode. Potentials of the electrodes connected through a 1000-ohm resistance are shown on the diagram (Figure 7). In the course of the first fortnight of the experiment the potentials increased markedly and the EMF decreased. Afterwards the potentials and EMF become rather stable. No exchange of the cathodic and anodic functions of the electrodes occurred and after 25 days the true potential difference of the disconnected electrodes is still very great (about 600 mv). After 40 days the true potentials are —570 mx (zinc electrode) and —160 mv (aerated iron electrode).

Copper-Copper DA-Cell

The time-potential curves of a DA-cell with copper electrodes are shown on the diagram (Figure 9). When the electrodes had been connected through a 1000-ohm resistance the potential difference was not detectable with the potentiometer used. The disconnected electrodes show a potential difference less than 5 mv with a higher potential of the non-aerated electrode. This phenomenon has been described and explained by Evans.[5]

Interruption of the water flow has a pronounced diminishing effect on the potentials of both electrodes. Reproducibility of the measurements was not very good and the cell shows a high internal resistance which in this case renders the long automatic recording impossible.

Copper-Zinc DA-Cells

The diagram in Figure 10 shows the potentials of a DA-cell with a Cu-cathode and Zn-anode connected through a 1000-ohm resistance. The EMF of such a cell is rather high but shows a tendency to decrease. The increase of potentials is due to the ennoblement of the potential of zinc electrode.

Summary

The behavior of zinc in a DA-cell indicates that the corrosion of the zinc could also be due to the action of the differential aeration currents as in the case of iron. The range of obtained potential differences is smaller than with iron. The addition of Calgon depresses the potentials of both the cathode and anode as a result of the formation of adsorption layers which inhibit access of oxygen to the metal surface. Calgon has a greater effect on the decrease of the potential of the cathodic, easier accessible surface and in this way depresses the potential difference or even changes it to negative values, thus practically eliminating the corrosion.

After some weeks zinc becomes cathodic against iron in the DA-cells where the zinc surface is exposed to an aerated water stream and the iron electrode placed in stagnant water. That explains the tuberculation and pitting in galvanized iron pipes in the same way as described in the preceding paper for iron.

Ennoblement of the potential of zinc is reversible when the water flow decreases.

Some other aspects of the DA-cells with zinc, iron and copper electrodes are discussed.

References

1. J. L. Mansa and W. Szybalski. *Acta Chem. Scand.*, **4**, 1275 (1950).
2. E. J. Davis. *Power*, **82**, 831 (1938).
3. L. W. Haase. *Metalloberflache*, **1**, 73 (1947).
4. G. Schikorr. *Trans. Electrochem. Soc.*, 76, 247 (1939).
5. H. Rotters and F. Eisenstecken. *Archiv Eisenhuttenw*, **15**, 59 (1941).
6. U. R. Evans. Metallic Corrosion, Passivity and Protection. London p. 365, (1946).
7. P. T. Gilbert. *Sheet Metal Ind.*, **25**, 2003 (1948).
8. R. B. Hoxeng and C. F. Prutton. *Corrosion*, 5, 330 (1949).

Potential and Current Requirements For the Cathodic Protection of Steel in Soils*

By W. J. SCHWERDTFEGER and O. N. McDORMAN*

Abstract

Potentials of steel in 20 airfree soils varying in pH from 2.9 to 9.6 were determined in the laboratory. These data and the potential-pH relation for the hydrogen electrode were used in fixing the optimum potential for the cathodic protection of the steel against corrosion. The effectiveness of this potential for the cathodic protection of steel in soils was confirmed by weight loss measurements on electrodes which were maintained at the selected potential in five corrosive soils. Cathodic polarization curves are interpreted in terms of the potential and current requirements for the cathodic protection of steel in soils.

I. Introduction

CATHODIC PROTECTION of underground steel structures usually is accomplished by applying direct current of such magnitude that the structure assumes a certain potential with respect to a standard reference electrode. Experience with piping systems has indicated that the optimum potential for this protection is approximately —0.85 volt referred to a copper-copper sulphate electrode.[1] As potentials are measured while the applied current is flowing, an indefinite IR drop between the reference electrode and the electrical boundary of the corrosion circuits may be included. Consequently, the true potential of the corroding surface is not known. Although underground structures maintained at this potential are probably not materially affected by corrosion, the theoretical and experimental basis for —0.85 volt as applicable to all soil environments has never been stated.

By applying electrical theory to the behavior of galvanic couples, Mears and Brown[2] deduced that cathodic protection is achieved when the potentials of the local cathodes are brought by polarization to the open-circuit potential of the most anodic element. In soils, differences in potential exist on the surface of buried steel structures, in effect forming galvanic couples. The problem then is that of determining a critical potential generally applicable to steel in soils.

The concentration of ferrous ions in equilibrium with iron in airfree water is very small in the alkaline range.[3,4,5] Gatty and Spooner[6] cite references indicating that the potential of iron in airfree solutions is a function of the hydrogen-ion concentration of the solution, the potential increasing in the anodic direction with increasing values of pH. Consequently, it appears that the rate of corrosion of iron in a solution may be reduced to a negligible value by polarizing the surface of the metal to a potential corresponding to a pH value at which the concentration of ferrous ions is small. Although no exact relation would be expected between the potential of iron and hydrogen-ion concentration in airfree soils differing widely in composition, an approximate evaluation of the critical potential at which iron would be subject to negligible corrosion appears feasible. This requirement for cathodic protection may be subjected to experimental verification by maintaining weighed electrodes exposed to normal corrosion in soils at the selected potential for a considerable period of time.

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*Both with National Bureau of Standards, Washington, D.C.

II. Potential of Steel in Airfree Soils

Potentials of steel electrodes** were measured in 20 airfree soils ranging in pH from 2.9 to 9.6 and in resistivity from 60 to 17,800 ohm-cm. Each soil was finely ground and saturated with water, and then mechanically worked and carefully packed into a Lucite cylinder 1.75 inch (45 mm) inside diameter by 2 inches (51 mm) long. The steel electrode was a disc 1.73 inch (44 mm) in diameter by 0.125 inch (3.2 mm) thick with machined surfaces. One surface of the disc after degreasing was scratched with 1G French emery paper. With this surface adjacent to the soil at one end of the cylinder while the other end rested on a flat surface, the disc was manually pressed with an oscillatory motion until the soil began to ooze out around the edge, indicating that good contact between steel and soil had been secured. After removing the excess soil from the edge of the disc and cylinder, molten asphalt was applied around the edge of the disc to hold it and to serve as an air seal. A circular piece of No. 16 mesh stainless steel screen with a 0.25 inch (6.4 mm) hole in the center was pressed against the soil at the other end of the cylinder. Then, molten asphalt was applied over this entire area excepting the hole which permitted release of the soil pressure and served as an area of contact for the referenc electrode. The soil cells were individually confined in a water saturated atmosphere and removed only for such time as was required for daily potential measurements, which were made with a potentiometer. The potentials of triplicate cells became relatively steady and varied less than ±5 mv, indicating that oxygen had been effectively excluded or consumed by corrosion. Stabilization at the most anodic potentials occurred within a period of ten days.

** Composition of steel in percentages: 0.23 C, 0.58 Mn, 0.008 P, 0.025 S, 0.095 Si, 0.077 Cu.

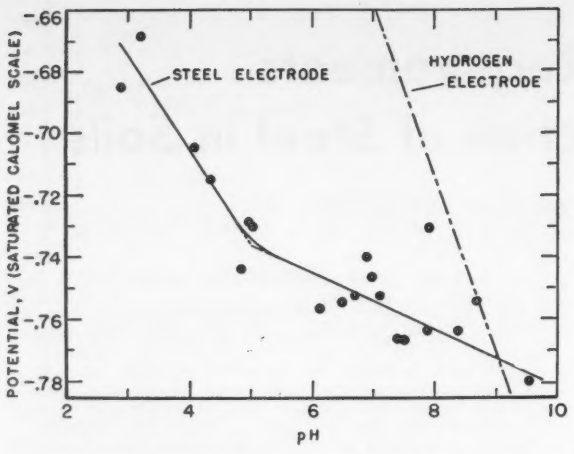

Figure 1—Relation between the potential of steel in air free soils and the pH values of the soils.

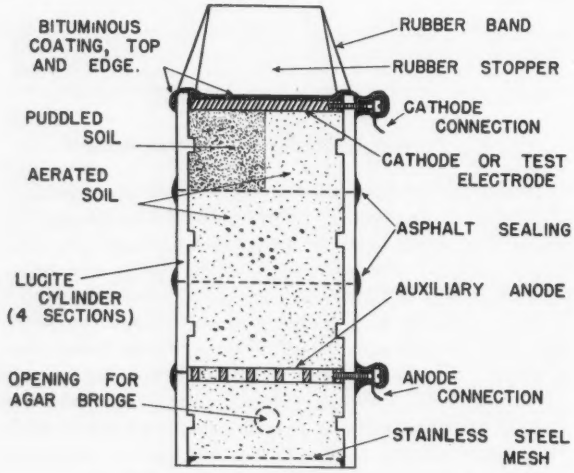

Figure 2—Details of experimental corrosion cell.

The values of the potentials of the steel electrodes in the different airfree soils vs the pH values of the corresponding soils are shown in Figure 1. Each point represents the average of four potential measurements made on as many consecutive days after stabilization of the electrodes. The rather wide dispersion of the values for soils having approximately the same hydrogen-ion concentration, results from the fact that the potential of steel in aqueous electrolytes is determined by the composition as well as by the hydrogen-ion concentration of the electrolyte. The curve is similar to curves representing the potential of iron as a function of hydrogen-ion concentration in different aqueous electrolytes.[6] In fact, it may be considered as a composite of the potential-pH curves for different salt solutions reported in the literature.

Corey and Finnegan[5] report that the hydrogen-ion concentration of waters in which iron is in equilibrium with ferrous hydroxide is between 8.3 and 9.6 depending on the composition of the waters and other factors. Since the curve in Figure 1 is a composite for various soils it would be reasonable to select a critical potential based on the average pH value reported in the literature, such as pH 9. It will also be observed in Figure 1 that at this value the potential curve for the standard hydrogen electrode at atmospheric pressure intersects the potential curve for steel. According to Holler[7] corrosion is reduced to a negligible amount at this point since there is no difference of potential between the hydrogen and steel electrodes. The potential at this intersection, approximately —0.77 volt, therefore is considered as the protective potential. (This potential is equivalent to —0.53 volt on the standard hydrogen scale.)

III. Properties of the Soils Used in The Study of Cathodic Protection

The samples of soil for the study of cathodic protection were taken from five of the National Bureau of Standards soil corrosion test sites. The soils vary considerably with respect to their physical properties and the composition of the water-soluble matter (Table I). All of these soils are severely corrosive toward ferrous metals as is evidenced by their low resistivities. Specimens of 1.5 inch (38 mm) steel pipe of standard wall thickness 0.145 inch (3.7 mm) were perforated within eight years in soil No. 64.

IV. Experimental Methods

The experimental corrosion cell in which the test electrode* was subjected to corrosion by differential aeration is shown in Figure 2. The cell was made up with four Lucite sections. Differential aeration was accomplished by puddling half the soil of the top section and wetting the other half under a suction of 30 cm. of mercury. The soil of the other three sections also was moistened under suction. The suction apparatus consisted of flasks fitted with Buchner funnels of the fritted glass type. After packing the puddled soil into one-half of the top section, the four sections were set up inside the funnels.

Dry soil, previously passed through a No. 20 mesh sieve was packed into each section. Water dispensers which provided for uniform distribution of distilled water were set up over the dry soil of each section. The rate of moistening the soil was controlled by the degree of suction and by the characteristics of the soil.

The perforated steel electrode (Figure 2) was the auxiliary anode, the perforations permitting air to pass through to the test electrode from the bottom of the cell. The stainless steel screen kept the soil intact.

The component parts were held together by asphalt, which also served as a sealer. The rubber band placed longitudinally around the cell applied pressure to the test electrode through the rubber stopper. Since the asphalt was pliable, this pressure assured contact between steel and soil.

The only part of the test electrode subject to corrosion was the machined surface adjacent to the soil. The surface was prepared by degreasing and scratching with 1G French emery paper. The edge and top side were coated with a bitumastic compound. Elec-

* See preceding footnote for composition.

trical connections to the electrodes were made through steel screws which had wires soldered to the heads.

Potential measurements were made through an agar bridge at the lower side of the cell.

The cell was stored in a friction top can containing a small quantity of water to keep the air saturated with moisture. The cell was placed above the water level and was not removed for the duration of the study. Wires from the electrodes were brought through holes in the side of the can. The can also was fitted with a hole for insertion of the agar bridge. When potential measurements were not being made, the bridge was removed and the hole was sealed.

Each cathodic protection test was of 60 days duration. Several cells were assembled with each soil and cells for any one soil were operated concurrently. The corrosion rates in such a group of cells were reproducible within a standard error of about 8 percent. All cells were permitted to react freely for a period of approximately 48 hours before applying protective currents. The weight losses which occurred during this period were calculated from cathodic and anodic polarization curves such as described by Holler[7] and Pearson.[8] The cathodic polarization curves also are interpreted in connection with the current required for protection, to be discussed later. Cathodic polarization data obtained at the conclusion of the 60-day period were similarly plotted. In obtaining the data it was found necessary to apply approximately equal increments of current at regular intervals. An arbitrary interval of three minutes was used.

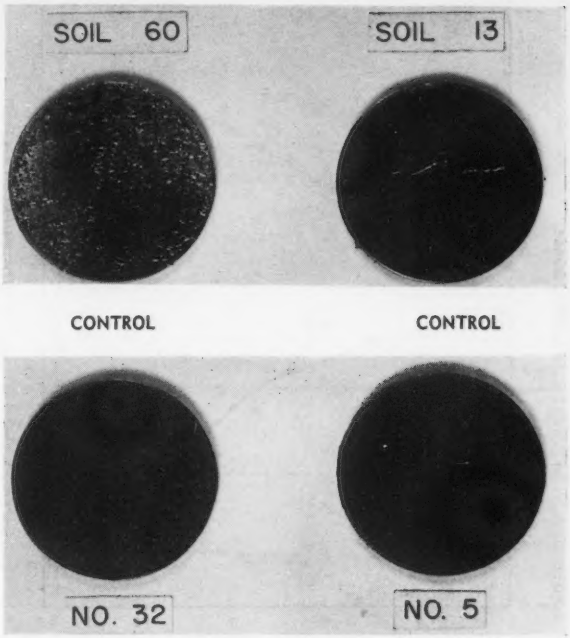

Figure 3—Unprotected (control) and protected steel electrodes in soil 60 (pH 2.9) and soil 13 (pH 9.5). Exposure 60 days. Protected cathodes 32 (soil 60) and 5 (soil 13) were maintained at potential —0.77 volt (saturated calomel scale) after 48 hours without protection.

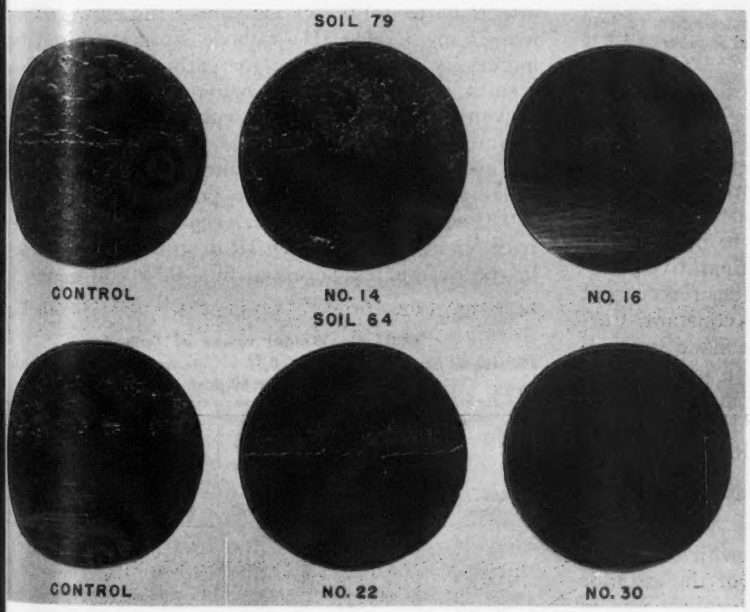

Figure 4—Effect of potential in cathodic protection. Exposure 60 days. Partially protected cathodes 14 (soil 79) and 22 (soil 64) failed to polarize. Protected cathodes 16 (soil 79) and 30 (soil 64) were maintained at —0.77 volt (saturated calomel scale) after 48 hours without protection.

Dry cells (1.5 volt) were used as a source of external power. The test electrode (cathode) was maintained at the desired potential by applying a constant voltage between the cathode and the auxiliary anode. The voltage was obtained from a variable voltage divider connected across the dry cell. The voltage

TABLE I—Properties of the Soils

SOIL							COMPOSITION OF WATER EXTRACT—MILLIGRAM EQUIVALENTS PER 100 g OF SOIL						
Number[1]	Type	Location of Test Site	pH	Resistivity at 60° F Ohm-cm	Aeration[2]	Total Acidity (Mg-eq/100 g of Soil)[3]	Na+K as Na	Ca	Mg	CO_3	HCO_3	Cl	SO_4
13	Hanford very fine sandy loam	Bakersfield, Calif.	9.5	290	G	A	6.23	0.09	0.13	0.00	1.12	1.64	3.76
60	Rifle peat	Plymouth, Ohio	2.9	218	P	297.4	2.91	10.95	2.86	.00	0.00	0.00	56.70
64	Docas clay	Cholame, Calif.	7.9	62	F	A	28.10	2.29	0.76	.00	.89	28.80	0.26
78	Caddo fine sandy loam	Latex, Texas	4.5	821	P	24.0	1.06	0.18	.31	.00	.00	0.82	.74
79	Tidal marsh	Freeport, Texas	7.9	324	P	A	6.22	.40	.31	.00	3.42	2.99	1.01

[1] Soil number also refers to site number as specified in Bureau soil corrosion tests.
[2] Aeration of soils: G, good; F, fair; P, poor.
[3] A indicates absence of acidity because of alkaline reaction.

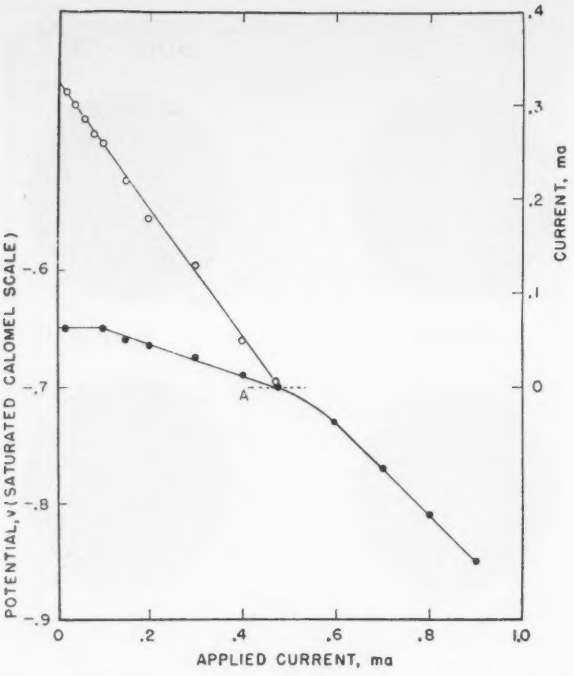

Figure 5—Current and potential relations of separated steel electrodes in a different aeration cell during cathodic polarization. o, cell current; • couple potential; A, open-circuit potential of anode = —0.70 volt.

was adjusted to provide the required current which was measured with a zero-resistance milliammeter. Thus, the amount of current flowing to the cathode depended on the potential of that electrode. A change in chemical polarization of the cathode affected the applied current in such a way so as to oppose that change. The auxiliary anode was comparatively unaffected by anodic polarization at the desired current and the cell resistance was relatively constant. Current and potential measurements were made approximately every 48 hours. The protective potential, in general, was maintained within ±15 mv. All potential measurements were made by the Hickling interrupter method as adapted for use with soils.[9]

V. Protection Obtained by Maintaining A Fixed Potential

The degree of cathodic protection which was obtained by maintaining the potential of the cathode at —0.77 volt with respect to the saturated calomel electrode is indicated by the weight losses given in Table II. The weight losses of the cathodes attributable to the freely corroding period have been deducted from the losses shown in the table. Because the potentials of nearly all the cathodes departed more or less from the critical potential of —0.77 volt for different periods of time, the extent of the departures with respect to potential and time are given in Table II. It will be observed that the weight losses of the cathodes in all of the soils are small compared with the weight losses of the controls, especially of those cathodes whose potential deviated little, if at all, from —0.77 volt. As may be expected, the results summarized in Table II show that larger weight losses for any given soil are associated with the greater deviations (less negative) than the critical potential (—0.77 volt). Figures 3 and 4 include photographs of some of the cathodes and their corresponding controls for which data are included in Table II. Some of the corrosion shown in the photographs of the protected specimens of course occurred during the freely corroding period of 48 hours. The fact that corrosion was not completely prevented in any of the soils is consistent with the results of Mears and Bialosky[10] who reported small residual weight losses for cathodically protected specimens. These investigators attributed such losses to incomplete protection during the period before cathodic protection became wholly effective. The weight loss in soil 60 of a cathode having a somewhat different potential (—0.69 volt) than the critical potential (—0.77 volt) for 12 of the 60 days was 84 mg (Table II—cathode No. 1), while a change to only —0.75 volt for 18 of the 60 days resulted in a weight loss of 40 mg (Table II—cathode No. 32). However, the weight loss accompanying a greatly increased potential (in a negative direction) to —1.0 volt for almost the entire 60 days was 27 mg (Table III—cathode No. 2), which is not materially less than that for cathode No. 32. These results indicate that corrosion cannot be entirely prevented and that —0.77 volt is the approximate optimum protective potential.

This is in accord with Kuhn's statement that polarizing an iron structure to potentials greater than —0.85 volt (Ref. Cu-$CuSo_4$) represents wasted electrical energy.[1] How much IR drop is included, if any, in the designated potential of —0.85 volt cannot be

TABLE II—Weight Losses of Cathodes
Maintained at approximately —0.77 v (referred to saturated calomel) for 60 days.

Soil Number	Cathode Number	WEIGHT LOSS OF ELECTRODES		AVERAGE POTENTIAL OF THE CATHODES DURING THE PERIOD OF DEPARTURE FROM —0.77 v.	
		Cathode	Control	Days of Departure	Potential
		Mg.	Mg.		v
13	5	8	431	0	—0.77
64	30	6	196	5	.76
78	19	19	111	3	.75
60	32	40	519	18	.75
60	1	84	519	12	.69
79	16	19	364	7	.74
79	13	28	364	14	.69

TABLE III—Potential Changes and Weight Losses of Cathodes
Receiving current indicated by the break in cathodic polarization curves—exposure 60 days.

Soil Number	Cathode Number	Weight Loss of Electrodes		Potential At the Break v	Average Potential of the Cathode[1]			
					Less Than —0.77 v		Greater Than —0.77	
		Cathode mg	Control mg		Days	Potential v	Days	Potential v
78	21	5	111	—0.69	3	—0.74	57	—0.77
79	25	14	364	.71	7	.75	53	.77
60	2	27	519	.74	3	.76	57	1.00
13	6	9	431	.72	21	.72	39	1.50
64	22	119	196	.73	60	.68	0	.....

[1] Potential referred to the saturated calomel half-cell.
[2] Current reduced to maintain potential indicated.

definitely stated. (The value of —0.77 volt referred to saturated calomel, which is free of IR drop outside of the electrical boundary, is equivalent to —0.85 volt referred to a copper-copper sulfate reference electrode apart from any equivalent IR drop.)

VI. Interpretation of Cathodic Polarization Curves in Cathodic Protection

Breaks in cathodic polarization curves have been interpreted by Ewing,[11] Pearson,[12] Denison and Romanoff[13] and Holler[7] in terms of the current and potential requirements for cathodic protection in soils. However, the data pertaining to significant changes in potential or current noted by these investigators have been based chiefly on theoretical considerations. Also, the effect of time on chemical polarization as related to critical current densities has received scant attention. Limitations of polarization curves in certain environments for determining the current required for cathodic protection have been pointed out by Mears and Bialosky.[10] These investigators concede that breaks in cathodic polarization curves have definite significance when the rate of corrosion is determined wholly by the cathode reaction (cathodic control). For the special condition that the observed potential of a corroding metal is the same as that of the anode on open-circuit, the break in the curve indicates that the entire surface has become cathodic. However, under most natural environmental soil conditions, the potential of iron with respect to a standard reference electrode is considerably less negative than the potential of iron in the same environment with air excluded. For such natural conditions the significance of breaks in cathodic polarization curves with respect to cathodic protection is not so readily understood.

In a study of the polarizing characteristics of dissimilar metals, Brown and Mears[14] showed that breaks in a composite cathodic polarization curve of a series of metals connected together in an electrolyte coincided with the open-circuit potential of the more anodic metal. Hence, in a differential aeration cell, a break in the cathodic polarization curve would be expected to occur at the open-circuit potential of the anode. Experimental verification of this was obtained with a corrosion cell set up similar to those already described, except that the electrode was cut into equal segments which were separated to permit measurement of the cell current. Figure 5 illustrates the electrical relations which were observed. It will be noted that a change in the polarization rate occurred around the open-circuit potential of the anode, namely —0.70 volt, at which potential the cell current was reduced to zero. Because the potential of —0.70 volt was the average potential of a large number of local couples on the anode, polarizing the couple to this potential would not eliminate local couples whose potentials were greater (more negative) than —0.70 volt. In order to effectively inhibit corrosion it would have been necessary to increase the potential of the experimental couple to —0.77 volt.

Typical cathodic polarization curves obtained on the solid electrode of one of the experimental cells,

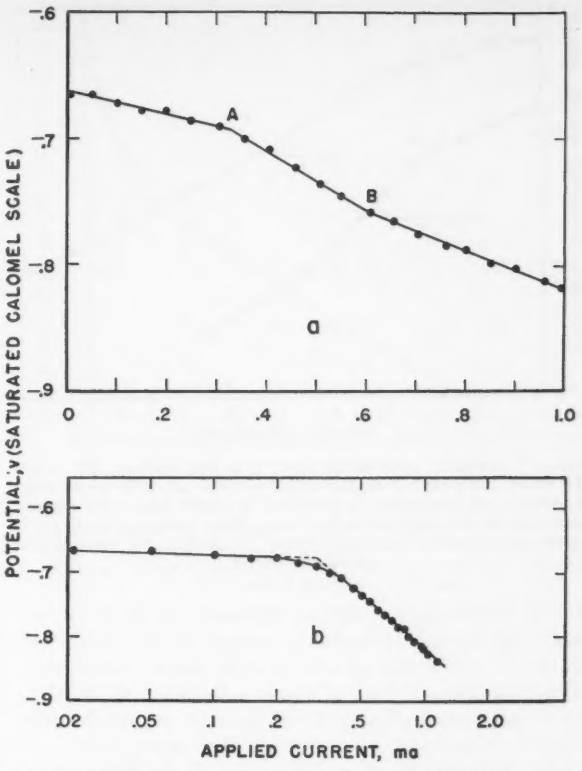

Figure 6—Cathodic polarization curves of a single steel electrode in a differential-aeration cell. a—plotted on rectangular coordinates; b—on semilogarithmic coordinates.

plotted on both rectangular and semi-logarithmic coordinates are shown in Figure 6a and b, respectively. Two breaks are indicated in Figure 6a, point A corresponding to the average open-circuit potential of the anode of the cell, and point B corresponding to the beginning of the hydrogen overvoltage portion of the curve. An approximation of the current indicated by A (Figure 6a) is obtained from the semi-logarithmic curve (Figure 6b) by the intersection of the extended dashed straight line portions of the curve. The straight line part of the semi-logarithmic curve at currents greater than the extrapolated value represents the hydrogen overvoltage. The beginning of the hydrogen overvoltage curve does not always appear as a distinct break (B) in the rectangular plot but sometimes appears as a gradual decrease in the polarization rate. Although the current indicated by A (Figure 6a) would not be sufficient initially to eliminate all local corrosion on the surface of an electrode it is reasonable to expect that the drift in potential caused by the continuous application of the current indicated by the break would be sufficient to polarize the surface to the protective potential and thereby to provide cathodic protection.

In order to determine the effectiveness of the current indicated by the break A (Figure 6a) as a requirement for cathodic protection, corrosion cells were set up as described in section IV and currents indicated by the breaks A in the cathodic polarization curves for the five soils studied were applied

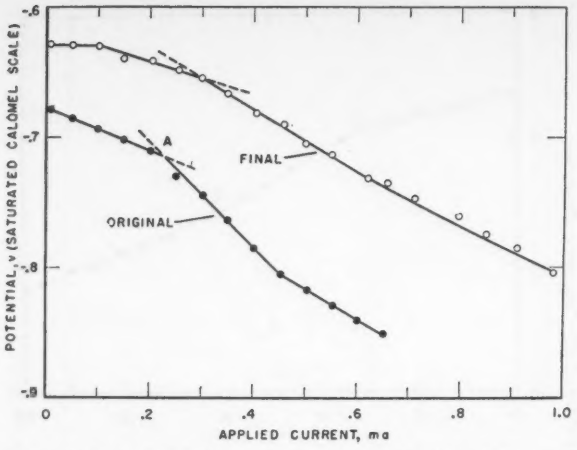

Figure 7—Cathodic polarization curves of a steel cathode (22) in soil 64 before and after the application of external current A for 60 days. Protection was incomplete, as indicated by weight loss of 119 mg and reoccurrence of a break in the final curve. Note: In four of the five soils tested the current at A was sufficient to polarize the cathode and provide protection.

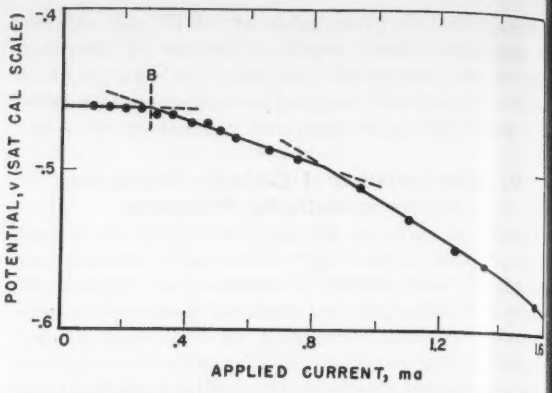

Figure 8—Cathodic polarization curve of a steel cathode (8) in soil 13 before the application of protective current. B, minimum protective current, which maintained a cathode potential of —0.77 volt.

to the previously weighed cathodes. In four of the soils the cathode potentials drifted to the protective value of —0.77 volt in from 3 to 21 days (Table III). The cathodes of two of these cells were allowed to drift to potentials greater than the protective potential while the cathodes of the other two cells were maintained at —0.77 volt. A comparison of weight losses of the cathodes with losses of the respective control electrodes (excepting in soil 64 which will be discussed later) shows that the degree of protection is good. The data for cathode No. 6 furnish additional evidence that polarization to a potential greater than —0.77 volt produces no appreciable further reduction in weight loss. This will be noted by comparison with the data for cathode No. 5 in Table II, in which case no actual benefit is indicated. Cathode No. 2 has already been referred to in section V in this same connection.

The rapid drift in potential of cathodes No. 2, 21 and 25 (Table III) to the protective value is consistent with the low weight losses of these electrodes. On the other hand, electrode No. 6, exposed to the very corrosive soil 13, lost negligible weight in spite of the fact that its average potential (—0.72 volt) for 21 days was considerably less negative than the protective potential. This apparent anomaly is to be explained by the fact that local corrosion in soil 13 is generally negligible. The relative absence of local corrosion is well illustrated by comparing the photographs of the control electrodes (soils 13 and 60) in Figure 3. However, even in alkaline and well aerated soils such as soil 13, the possibility of pitting cannot be ignored. Should air be totally excluded from the surface of steel in such soils, polarization to the protective potential would be required.

The fact that the potential of cathode No. 22 (soil 64) did not drift to the protective potential during the period of the test is not an indication that the current corresponding to the break in the cathodic polarization curve is insufficient for cathodic protection. The failure of the potential of cathode No. 22 to reach the protective value is attributed to selecting the applied current before the maximum rate of corrosion developed. Therefore, the current applied for cathodic protection was insufficient. The increase in the corrosion rate of cathode No. 22 during the course of the test is shown by the fact that the break in the cathodic polarization curve obtained at the conclusion of the test indicated a greater current requirement than the curve obtained at the beginning (Figure 7).

In maintaining the cathodes in the five soils at the protective potential the effect of chemical polarization resulted in a reduction of the applied current (Table IV). In four of the soils a steady value of current, indicated as the minimum in Table IV, was reached in from 14 to 21 days after the current was initially applied. The reduction of current in the case of cathode No. 30 (Table IV) although slight, occurred progressively over the 60 day period. Elimination of local couples by diffusion of alkali over the surface of this cathode progressed slowly because of the preponderance of soluble chloride in soil 64. It is probable that the applied current could have been reduced even more had the length of the test period been extended.

The average corrosion currents calculated from the weight losses of the control electrodes by the application of Faraday's law (Table

TABLE IV—Current Required for Cathodic Protection—Exposure 60 Days

Soil Number	Cathode Number	Weight Loss of Electrodes		Protective Current Applied to Cathode[1]		Average Current Calculated From Weight Loss of Control By Faraday's Law	Current Indicated By Departure From Relatively Constant Potential on Original Cathodic Polarization Curve of Cathode
		Cathode mg	Control mg	Initial ma	Minimum ma	ma	ma
13	8	12	431	3.90	0.28[2]	0.29	0.28
60	32	40	519	1.27	.24[2]	.35	.30
78	19	19	111	0.20	.05[2]	.07	.06
79	16	19	364	.88	.24[2]	.24	.16
64	30	6	196	.68	.55[3]	.13	.15

[1] Cathode maintained at —0.77 v ± .015 v (Referred to saturated calomel).
[2] Minimum steady current after 14 to 21 days.
Minimum current after a progressive decrease for 60 days.

IV) indicate in most cases that the minimum current required for cathodic protection is about equal to the average current associated with corrosion. Thus, the high initial currents required for protection are partly attributable to the higher initial corrosion rates. Denison and Romanoff studied the behavior of zinc-steel couples underground[13] and their results suggested that no more current is required for the cathodic protection of steel than that calculated by Faraday's law for loss in weight produced by normal corrosion.

At low values of applied current the potential of a corroding electrode is relatively constant (Figure 8). The currents at which the corresponding potentials depart from relatively constant values are given in the last column of Table IV. For cathode No. 8 this value is shown at B in Figure 8, which is characteristic of the curves used for obtaining the other values in the last column. In the case of the four cathodes which had stabilized after 21 days, there is fair agreement between the minimum current which actually maintained protection and the values in the last column. Apparently the point of departure on the initial cathodic polarization curve of the electrode potential from a relatively stable value, designates the applied current necessary to maintain a balance between the consumed and available oxygen after a cathodically protective alkaline film has been established on the electrode surface.

The close relation between the current required for protection and that associated with corrosion was probably applicable over the greater part of the 60 day period, therefore suggesting that initially applied currents smaller than those indicated would not have been sufficient for protection. Consequently, the minimum current finally required for cathodic protection must not be confused with the current initially required. To verify this statement additional cells were assembled with soils 78 and 79 and the respective minimum currents, as indicated by the departure of cathode potentials from relatively constant values on the original cathodic polarization curves, were applied to the electrodes for the duration of the 60 day test period. The weight losses of these electrodes were as large as the losses associated with the corresponding controls. The potential of the cathode in soil 78 remained substantially unchanged during the test period while the potential of the cathode in soil 79 actually became less negative. A photograph of the cathode in soil 79 (No. 14) together with the corresponding control is shown in Figure 4. Field investigations in soils with pipe coupons show that a change in pipe potential to a more negative value is essential for a reduction in corrosion.[15]

At the conclusion of the 60 day test period all cathodes were placed on open-circuit. After a period of about 15 hours, required for stabilization of the cathode potentials, a cathodic polarization curve again was obtained on each electrode. The curve for cathode No. 8 which is shown in Figure 9, is typical of all the curves obtained on the completely protected electrodes. The noble potential on open-circuit is due to the formation of an oxide film on the electrode surface. The polarization curve shown in Figure 9 is

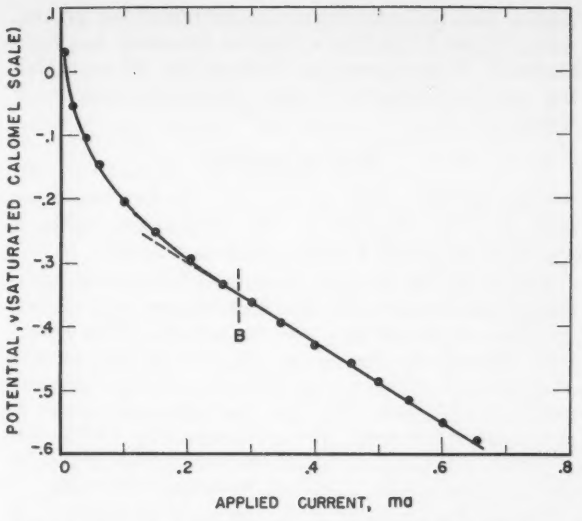

Figure 9—Cathodic polarization curve of cathode 8 in soil 13 (See Figure 8) after the application of protective current for 60 days. B, minimum protective current, which maintained a cathode potential of —0.77 volt. Weight loss = 12 mg.

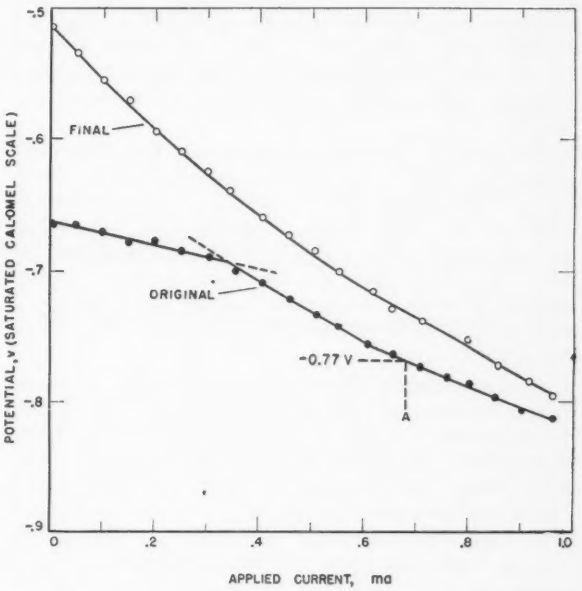

Figure 10—Cathodic polarization curves of a steel cathode (30) in soil 64 before and after the application of protective current for 60 days. A, current initially applied, subsequently varied, to maintain potential of —0.77 volt. Weight loss = 6 mg.

typical of a true cathode and, of course, reveals the absence of corrosion. It will be noted that, here again, B denotes the minimum current required for protection and that an inflection occurs at this point. It cannot be ascertained whether this inflection has any significance because it was not apparent on the final curves for all protected specimens (Figure 10). Here again in Figure 10, the absence of a break in the final curve is consistent with the neglible weight loss which occurred on cathode No. 30. The occurrence of a break, after having applied current for a period,

shows that the current was insufficient for protection (Figure 7) or that a state of corrosion has been resumed. A photograph of cathode No. 22 on which the curves of Figure 7 were obtained is shown in Figure 4.

VII. Summary

The cathodic protection of steel in five corrosive soils was investigated in the laboratory, using a specially designed differential-aeration cell.

The most significant requirement for cathodic protection was found to be the maintenance of a critical potential at the surface of the cathode. This potential, defined by the point of intersection of the potential-pH curve for steel in airfree soils and the potential-pH curve for the hydrogen electrode at atmospheric pressure, was approximately —0.77 volt, referred to the saturated calomel electrode, or —0.53 volt referred to the standard hydrogen electrode.

Electrodes maintained for 60 days at —0.77 volt lost negligible weight under conditions which produced severe corrosion of unprotected electrodes simultaneously exposed in the same soils.

Referred to the copper-copper sulfate electrode, the protective potential is approximately —0.85 volt, which is in agreement with the practice for cathodic protection used by many corrosion engineers, in those cases where the measurements are free of IR drop external to the electrical boundary of the corrosion circuit.

The current required to maintain the protective potential (—0.77 volt) diminished to fairly stable values after about three weeks for four of the five soils tested. This limiting value of current, which just maintains the protective potential, differs for different soils. These limiting values were in good agreement with the average current associated with the normal rates of corrosion of the unprotected electrodes.

A characteristic break in the cathodic polarization curve for steel in soil is interpreted as indicating the minimum current initially required for cathodic protection. Although the electrode potential corresponding to this current may be considerably less negative than the protective potential, it was found that the potential generally drifted to the critical protective value before appreciable corrosion occurred.

Cathodic polarization curves obtained for protected electrodes at the conclusion of the test were similar to those obtained for insoluble electrodes, thereby indicating that cathodic protection had been achieved.

References

1. Robert J. Kuhn. *Proc. Am. Petroleum Inst.*, **14**, Sec. IV, 153 (1933) Nov.
2. R. B. Mears and R. H. Brown. *Trans. Electrochem. Soc.*, **74**, 519 (1938).
3. John R. Baylis. *Ind. Eng. Chem.*, **18**, 370 (1926).
4. K. Murata. *J. Soc. Chem. Ind.* (Japan), **35**, 532 (1932).
5. Richard C. Corey and Thomas J. Finnegan. *Proc. Am. Soc. Test Mat.*, **39**, 1242 (1939).
6. O. Gatty and E. C. R. Spooner. The Electrode Potential Behavior of Corroding Metals in Aqueous Solutions. Oxford University Press, London (1938) p. 310.
7. H. D. Holler. *J. Electrochem. Soc.*, **97**, 277 (1950) Sept.
8. J. M. Pearson. *Trans. Electrochem. Soc.*, **81**, 485 (1942).
9. Robert B. Darnielle. *J. Research NBS*, **25**, 421 (1940) RP 1336.
10. R. B. Mears and J. M. Bialosky. Cathodic Protection Symposium, Electrochem. Soc. and Nat. Assn. Cor. Engrs. 37 (1949).
11. Scott Ewing. *Proc. Am. Gas Assn.*, 613 (1940).
12. J. M. Pearson. *Petroleum Engr.*, **15**, 6, 7, 8 (1944).
13. Irving A. Denison and Melvin Romanoff. *J. Research NBS*, **40**, 301 (1948) RP 1876.
14. R. H. Brown and R. B. Mears. *Trans. Electrochem. Soc.*, **81**, 455 (1942).
15. D. Holsteyn. *Elec. News* (Petroleum Ind. Elec. Assn.), **13**, No. 3 (1943).

DISCUSSION

Questions by R. V. Comeaux, Humble Oil & Ref. Co., Baytown, Texas:

1. The minimum current densities you found appear high (± 30 MA sq. ft. at 0.2 MA total current). Do you know what current densities are required to protect underground lines in these soils?

2. For the oxidation of an equivalent of iron at the anode in the cells without protection, a corresponding reduction of an equivalent of reducible material at the cathode was necessary. If we reduce the amount of reducible material (oxygen in this case) reaching the cathode, a corresponding reduction in the oxidation of the iron at the anode results. Have you tried to correlate the amount of corrosion you actually found on your specimens maintained at the various protective potentials with the rate of oxygen diffusion to the cathode surface?

Authors' Reply:

The minimum protective current densities varied between 3 and 17 ma/sq. ft. on the laboratory steel specimens exposed to the four soils in which stabilization occurred within 21 days. Since the laboratory soil cells were assembled to give accelerated rates of corrosion, the protective current densities indicated may be higher than would be required to protect steel in the same soils in the field. National Bureau of Standards field data obtained on ferrous specimens buried for 10 years in 60 locations throughout the United States reveal extreme weight loss variations of 40 to 1 in different soils, with variations of 5 to 1 being common. The laboratory data show that the current required for cathodic protection is proportional to the rate of corrosion. Consequently, the range of protective current densities required to protect iron in soils is indicated by the weight loss variations as shown by the field data.

No correlation was made between weight loss and the rate of oxygen diffusion on steel specimens maintained under cathodic protection. However, the authors believe that a direct relationship exists as indicated by cathodic polarization curves.

Discussion by Norman P. Peifer, Manufacturers Light and Heat Co., Pittsburgh, Pa.:

In your statement that current densities of 10 to 15 MA per square foot of metal surface, was required to protect the specimen under test, you did not state

the type or composition of the soil. I believe that the soil used must have a very low pH and would be what we generally classify as a sulfur swamp soil that results when sulfur water from coal mines saturates the soil.

If this is the case the corrosion would be of chemical nature. Under this type of attack the current required to protect the specimen would be greatly in excess of that required for normal soils. In fact, under such conditions we have found that the best protection is to coat the specimen or pipe line to reduce the exposed area and then apply cathodic protection to take care of the faults in the coating.

Authors' Reply:

Soil 60 used in the laboratory test fulfills the conditions referred to by Mr. Peifer. The protective current density is necessarily high because of the extremely high acidity of this soil. It is undoubtedly true that a good protective coating is an economical requisite when applying cathodic protection in such environments.

Questions by Mort LaFever, Public Housing Administration, Washington, D. C.:

1. You referred to the type of corrosion on control specimen in soil No. 60 as general corrosion, whereas you referred to type of corrosion on control specimen in soil No. 13 as galvanic corrosion. Is not all corrosion galvanic in nature except that attributed to anaerobic bacteria?

2. You referred to a pipe-to-soil potential of —.85 volt referred to the copper-copper sulfate half cell as the protected value. Where would you say that P/S measurements should be made?

Authors' Reply:

The reason for distinguishing between general corrosion and galvanic corrosion in the case of steel electrodes exposed to soils 60 and 13 respectively, lies in the nature of the corrosive attack. Galvanic Corrosion is usually referred to as occurring when a bi-metallic couple is exposed to an aqueous electrolyte. Actually, the corrosion of iron in such an electrolyte is in effect galvanic, as shown by Holler.[1] Corrosion of steel in soil 60 is referred to as general corrosion, because of the uniform attack over the entire exposed surface, whereas on steel exposed to soil 13 there is a distinct separation of anodic and cathodic areas such as would be evident on a bi-metallic couple similarly exposed.

Reply to Remark 2: For the protective potential to have significance all of the IR drop external to the electrical boundary of the corrosion circuit must be excluded.

1. H. D. Holler, *Corrosion* **7**, 52 (1951) Feb.

Discussions

Gasoline Resistant Tank Coatings by W. W. Cranmer. *Corrosion*, Vol. 8, No. 6, 195-204 (1952) June.

Question by H. F. Haase, Marquette University, Milwaukee, Wis.:

Have some of the zinc-silicate coatings such as Dimetcote (Amercote) or zincilate been tried?

Reply by W. W. Cranmer:

No zinc silicate coatings were tried during the earlier period of this investigation. So far as the author knows, none were available for trial at that time. More recently, laboratory tests of one commercial coating of this type were started. These tests are not complete, but the coating is still in a satisfactory condition after 38 weeks in test.

Questions by Kenneth Tator, Coraopolis, Pa.:

1. A previous paper, "Economics in Industrial Maintenance Painting," by R. R. Pierce* demonstrated the value of maintaining proper system thicknesses, and faulty performance experience when such minimum system thicknesses were not maintained. It is therefore important in the comparison of performances of two or more systems that such systems be tested at comparable system thickness. In Cranmer's work, three systems (polysulfide, vinyl and Saran) were comparatively evaluated. If such systems were applied at dis-similar system thicknesses the conclusions drawn may be a result of film thickness rather than the characteristics of the coating materials.

2. It is recognized that the performance of various protective coatings over steel is affected by the type of priming system used. Inasmuch as no reference was made to the primes in Cranmer's paper, it was desired that this point be elaborated.

* *Corrosion*, **8**, 5, 178-182 (1952) May.

Reply by W. W. Cranmer:

Question 1 has been answered on page 197 of the published article.

Answer to question 2.—The polysulfide type coating (proprietary) was self-primed. The vinyl-type coating (proprietary) consisted of one gray primer

shows that the current was insufficient for protection (Figure 7) or that a state of corrosion has been resumed. A photograph of cathode No. 22 on which the curves of Figure 7 were obtained is shown in Figure 4.

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References

1. Robert J. Kuhn. *Proc. Am. Petroleum Inst.*, **14,** Sec. IV, 153 (1933) Nov.
2. R. B. Mears and R. H. Brown. *Trans. Electrochem. Soc.*, **74,** 519 (1938).
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Questions by R. V. Comeaux, Humble Oil & Ref. Co., Baytown, Texas:

1. The minimum current densities you found appear high (± 30 MA sq. ft. at 0.2 MA total current). Do you know what current densities are required to protect underground lines in these soils?

2. For the oxidation of an equivalent of iron at the anode in the cells without protection, a corresponding reduction of an equivalent of reducible material at the cathode was necessary. If we reduce the amount of reducible material (oxygen in this case) reaching the cathode, a corresponding reduction in the oxidation of the iron at the anode results. Have you tried to correlate the amount of corrosion you actually found on your specimens maintained at the various protective potentials with the rate of oxygen diffusion to the cathode surface?

Authors' Reply:

The minimum protective current densities varied between 3 and 17 ma/sq. ft. on the laboratory steel specimens exposed to the four soils in which stabilization occurred within 21 days. Since the laboratory soil cells were assembled to give accelerated rates of corrosion, the protective current densities indicated may be higher than would be required to protect steel in the same soils in the field. National Bureau of Standards field data obtained on ferrous specimens buried for 10 years in 60 locations throughout the United States reveal extreme weight loss variations of 40 to 1 in different soils, with variations of 5 to 1 being common. The laboratory data show that the current required for cathodic protection is proportional to the rate of corrosion. Consequently, the range of protective current densities required to protect iron in soils is indicated by the weight loss variations as shown by the field data.

No correlation was made between weight loss and the rate of oxygen diffusion on steel specimens maintained under cathodic protection. However, the authors believe that a direct relationship exists as indicated by cathodic polarization curves.

Discussion by Norman P. Peifer, Manufacturers Light and Heat Co., Pittsburgh, Pa.:

In your statement that current densities of 10 to 15 MA per square foot of metal surface, was required to protect the specimen under test, you did not state

the type or composition of the soil. I believe that the soil used must have a very low pH and would be what we generally classify as a sulfur swamp soil that results when sulfur water from coal mines saturates the soil.

If this is the case the corrosion would be of chemical nature. Under this type of attack the current required to protect the specimen would be greatly in excess of that required for normal soils. In fact, under such conditions we have found that the best protection is to coat the specimen or pipe line to reduce the exposed area and then apply cathodic protection to take care of the faults in the coating.

Authors' Reply:

Soil 60 used in the laboratory test fulfills the conditions referred to by Mr. Peifer. The protective current density is necessarily high because of the extremely high acidity of this soil. It is undoubtedly true that a good protective coating is an economical requisite when applying cathodic protection in such environments.

Questions by Mort LaFever, Public Housing Administration, Washington, D. C.:

1. You referred to the type of corrosion on control specimen in soil No. 60 as general corrosion, whereas you referred to type of corrosion on control specimen in soil No. 13 as galvanic corrosion. Is not all corrosion galvanic in nature except that attributed to anaerobic bacteria?

2. You referred to a pipe-to-soil potential of —.85 volt referred to the copper-copper sulfate half cell as the protected value. Where would you say that P/S measurements should be made?

Authors' Reply:

The reason for distinguishing between general corrosion and galvanic corrosion in the case of steel electrodes exposed to soils 60 and 13 respectively, lies in the nature of the corrosive attack. Galvanic Corrosion is usually referred to as occurring when a bi-metallic couple is exposed to an aqueous electrolyte. Actually, the corrosion of iron in such an electrolyte is in effect galvanic, as shown by Holler.[1] Corrosion of steel in soil 60 is referred to as general corrosion, because of the uniform attack over the entire exposed surface, whereas on steel exposed to soil 13 there is a distinct separation of anodic and cathodic areas such as would be evident on a bi-metallic couple similarly exposed.

Reply to Remark 2: For the protective potential to have significance all of the IR drop external to the electrical boundary of the corrosion circuit must be excluded.

1. H. D. Holler, *Corrosion* **7**, 52 (1951) Feb.

Discussions

Gasoline Resistant Tank Coatings by W. W. Cranmer. *Corrosion*, Vol. 8, No. 6, 195-204 (1952) June.

Question by H. F. Haase, Marquette University, Milwaukee, Wis.:

Have some of the zinc-silicate coatings such as Dimetcote (Amercote) or zincilate been tried?

Reply by W. W. Cranmer:

No zinc silicate coatings were tried during the earlier period of this investigation. So far as the author knows, none were available for trial at that time. More recently, laboratory tests of one commercial coating of this type were started. These tests are not complete, but the coating is still in a satisfactory condition after 38 weeks in test.

Questions by Kenneth Tator, Coraopolis, Pa.:

1. A previous paper, "Economics in Industrial Maintenance Painting," by R. R. Pierce* demonstrated the value of maintaining proper system thicknesses, and faulty performance experience when such minimum system thicknesses were not maintained. It is therefore important in the comparison of performances of two or more systems that such systems be tested at comparable system thickness. In Cranmer's work, three systems (polysulfide, vinyl and Saran) were comparatively evaluated. If such systems were applied at dis-similar system thicknesses the conclusions drawn may be a result of film thickness rather than the characteristics of the coating materials.

2. It is recognized that the performance of various protective coatings over steel is affected by the type of priming system used. Inasmuch as no reference was made to the primes in Cranmer's paper, it was desired that this point be elaborated.

* *Corrosion*, **8**, 5, 178-182 (1952) May.

Reply by W. W. Cranmer:

Question 1 has been answered on page 197 of the published article.

Answer to question 2.—The polysulfide type coating (proprietary) was self-primed. The vinyl-type coating (proprietary) consisted of one gray primer

coat, three gray body coats, and three black seal coats. The author has no information as to the composition of the primer coat. The Saran-type coating was self-primed.

Question by W. Ronald Briggs, Briggs Bitumen Co., Philadelphia:

You mentioned a cost of $300 for coating a tank car with Saran lining. How did you arrive at that cost? What type of material and what method of application was used? What was your labor cost, at what rate, and what was your material cost? What is your cost per square foot in a typical application? Are these direct costs of labor and material only?

Reply by W. W. Cranmer:

The material used was the Saran-type. Thirty-five gallons were used for each car, at a cost of $3.00 per gallon. About five tons of sand were used for blasting, at about $5.00 per ton. Fifteen man-days labor were used, at an average cost of $13.00 per day. Total cost, labor and material, $325.00. The coating was applied entirely by brushing. No record of number of square feet coated per car is available. The capacity of the cars was 10,000 gallons. The above costs are direct labor and material costs.

Cathodic Protection at Steam-Electric Generating Stations by J. H. Collins and E. H. Thalmann. *Corrosion*, Vol. 8, No. 9, 314-320 (1952) Sept.

Discussion by Norman P. Peifer, Manufacturers Light and Heat Co., Pittsburgh, Pa.;

In most power plants the numerous conduit systems and extensive copper ground beds for plant protection will tend to shield the underground structures from cathodic protection currents. When a single rectifier and ground bed installation is used this shielding effect will make it necessary to use higher current densities to make the spread sufficient to protect outlying structures. This contributes to a maximum current density to the structures near the ground bed and minimum or even insufficient current to the remote structures.

The installation of multiple ground beds and associated ground beds would give a much better distribution of cathodic protection currents and eliminate the high current densities required when the single rectifier and ground bed is used.

Was this taken into consideration when the cathodic protection system was installed?

Reply by J. H. Collins:

Station networks are not favorable to the installation of a large number of ground beds or distributed anode systems and the long-line galvanic cells that are the most serious factor in station structure corrosion can be overcome by currents of reasonable value, distributed from one or two ground beds suitably placed outside the network. Current distribution to the grounding-grid copper is adequate and unshielded structure members are fully protected. In the interior of the network shielding limits the degree of protection against local corrosion conditions but these in general are less serious than the effects of the large-scale cells. Where warranted by local conditions separate cathodic protection installations should be provided for isolated or shielded members such as intake screens or cable runs.

Question by Gustave Heinemann, Columbia-Southern Chemical Corp., Corpus Christi, Texas:

Is system applicable to sea water installations?

Reply by J. H. Collins:

At sea-side stations cathodic protection is applicable to members continuously or intermittently submerged, in conjunction with other protective measures necessary for splash zone areas. Intake screens, circulating waterlines, condensers, cable runs, steel sheet piling or other members in contact with sea water generally are isolated or shielded. A station rectifier relieves such structures of the galvanic effect of station grounding copper but individual cathodic protection systems are required for their protection against the severe local effects of sea water immersion. Installations of the type shown in Fig. 10 applied to steel-frame copper-mesh screens in sea water have been in operation for 2½ years with very satisfactory results. An interesting secondary effect at two stations where marine growth is vigorous is an almost complete elimination of barnacles and mussels.

Question by H. A. Robinson, The Dow Chemical Co., Midland, Mich.:

How far is the rectifier ground bed from the nearest segment of the grid system being protected and what factors govern the separation?

Reply by J. H. Collins:

Separations range from 250 to 800 feet. The factors governing the separation are the conditions discussed under "Ground Bed Locations," the current output, and limitations imposed by boundary lines, foreign structures, etc. It is desirable to place the ground bed where the sensible limits of its potential gradient would not include any station structure. Where this is not practicable the resistance-to-earth of the closer structures is significant; a separation of 250 feet from a tank on a concrete mat may be more satisfactory than 500 feet from a switchyard grounding grid.

Question by Orville W. Zastrow, Rural Electrification Administration, Washington, D. C.:

Are calcareous deposits built up on the grounding grid?

Reply by J. H. Collins:

Current densities are so small that deposits are not great and not sufficient to affect resistance to earth of the grounding grid.

CORROSION CONTROL
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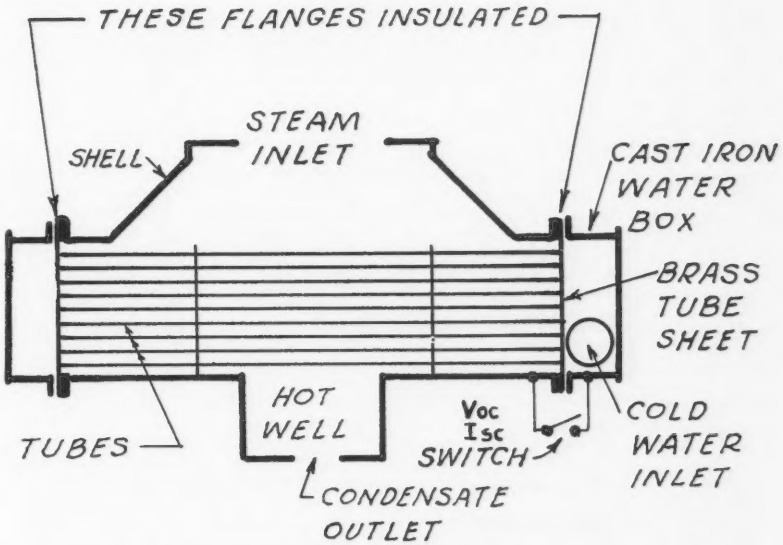
Topic of the Month

Graphitization of Cast-Iron Water Boxes On Surface Condensers Stopped by Insulation

By H. W. WAHLQUIST*

AN IMPORTANT corrosion problem encountered in steam-electric power plants is the graphitization that occurs on cast-iron water-boxes of surface condensers. The problem is particularly acute when sea water is used for cooling. Corrosion, with resulting graphitization of the water-box is chiefly due to the powerful galvanic cell formed by the anodic water-box in metallic contact with the cathodic tube-sheet which is usually constructed of brass or Muntz metal. There is in effect a huge short-circuited battery with current discharging to the cooling water from the interior surfaces of the water-box and collecting on the tube-sheet and tube ends, the circuit being completed through the flange bolts to the water-box. On large condenser units with unpainted surfaces the initial galvanic current flow can exceed 50 amperes where sea water of 25 ohm-cm resistivity is used for cooling. The current decreases with time as corrosion progresses, leaving a layer of graphite on the cast-iron surfaces and eventually a reversal may take place, the water-box becoming cathodic to the tube-sheet and tube ends.

An opportunity was afforded to check these effects by electrical measurements over a period of three years. Three surface condensers constructed for a new steam-electric station were provided with electrical insulation between the cast-iron water-boxes and tube-sheets by installing plastic sleeves and washers on the water-box flange bolts, and also insulating the flanges of auxiliary piping. This made it possible to measure the open-circuit voltages and short-circuit currents of the galvanic cells. Two of the condensers (No. 1 and 2) are 11,000 sq. ft. units and the third (No. 3) 45,000 sq. ft. The cooling water used in these condensers is sea water with varying amounts of fresh water dilution and measures in the order of 70 ohm-cm. Condenser No. 1 is operated with the flange insulation short-circuited, and No. 2 with the flange insulation open-circuited. Condenser No. 3 was initially operated with flange insulation open-circuited and later cathodically protected with magnesium anodes. The water-boxes had been painted with an oil-base zinc dust paint which greatly reduced the galvanic current as compared with values that would have been measured with unpainted surfaces.



SURFACE CONDENSER

WATER BOX INSULATED FROM TUBE SHEET AND SHELL

The initial potential of the galvanic cell formed by the cast-iron water-box and brass tube sheet was about 0.35 volt, and the short-circuit current about 2 amperes for Units 1 and 2 and 12 amperes for Unit 3. After operating with the insulation short-circuited for 18 months, the galvanic potential and current of Unit No. 1 had reduced to practically zero. Sixteen months later, measurements showed potentials and currents reversed, the water-box now being cathodic to the brass tube-sheet with open-circuit potential of .027 volts and short-circuit current of 0.26 amperes. Inspection of the water-box showed graphitization had progressed to depths of ⅛-inch to ⅜-inch at points where the paint coating had failed.

In Condenser No. 2, which had been operating with the insulation effective, no significant change occurred in the galvanic potential, and inspection showed that the graphitization observed in Condenser No. 1 had not developed in this unit. Similarly, on Condenser No. 3, which was open-circuited for five months and cathodically protected for fifteen months, no graphitization developed on the water-box. With this latter unit, a portion of the cathodic protection current can be directed to the tube-sheet and tube ends by means of a resistance bond across the insulated flange.

These tests show the importance of the brass and cast-iron galvanic cell in condensers of this type and suggest that where the flanges are not insulated, a good coating applied to the tube-sheet and tube ends will be more effective in controlling corrosion of the water-box than would a coating on the water-box itself. Severe graphitization of the water-box will occur if the water-box alone is coated, unless cathodic protection is installed. With both the tube-sheet and water-box coated, cathodic protection current requirements are greatly reduced. High-purity zinc anodes in such a case provide an efficient and effective current source.

* Electrical Engineer, Ebasco Services, Inc., 2 Rector St., New York 6, N. Y.

NACE News

Philadelphia Panel Discussion Is Well Attended

A corrosion problem round table discussion with a panel of four men was arranged for the October meeting of the Philadelphia Section. The four categories into which the discussion was divided and the respective leaders selected were: Metals and Alloys—T. P. May, International Nickel Co.; Inhibitors—George E. Best, Mutual Chemical Co.; Cathodic Protection—J. M. Pearson, Sun Oil Co. and Barriers (Paints and non-metallic liners)—F. Buckley, E. I. du Pont de Nemours.

Members were requested to submit their questions in advance, and were asked to present any other questions they might think of as the meeting progressed. The meeting was held at the Poor Richard Club, October 10.

Guests included officers from the New York, Baltimore and Pittsburgh Sections and the Northeast Region of NACE. A full house ate dinner at 6:30 p.m.

W. R. Briggs, Philadelphia chairman introduced Robert R. Pierce, moderator.

Clever presentation of controversial questions evoked several views on each subject, adding to the value of the free exchange of information and experience.

Some of the points covered were: How to ground a large oil tank associated with electrical generators, and how to protect it from lightning; requisites of primers for protective coatings; in practical tests how abrasive action of slurry can be taken into consideration; the length of time that selected concentrations of named inhibitors would be effective on mild steel in special environments; effectiveness of an anode in water that does not produce a calcareous deposit; the length of time that protection will continue in a system employing

(Continued on Page 3)

Record Attendance At Boston Section Hears L. P. Sudrabin

"Cathodic Protection," by L. P. Sudrabin, technical director of the Electro Rust-Proofing Corp., Belleville, N. J., drew the largest attendance at any meeting yet held by the Greater Boston Section. Sixty-five persons attended the social hour, dinner and evening meeting held October 1 at Hotel Beaconsfield, Brookline, Mass. There were 30 members and 35 guests.

The discussion topic for this meeting was an overwhelming first in a survey conducted to determine membership interest. Those attending the meeting, fourth of the recently formed Greater Boston Section, heard Mr. Sudrabin's slide-illustrated talk. A question and answer period followed the talk.

Committee activities reported during the business meeting indicated continued and growing interest in the section. Officers feel they have a good program scheduled for the 1952-53 season. Present plans are to hold the next meeting December 10 with Dr. H. P. Meissner of Massachusetts Institute of Technology as guest speaker.

NACE MEETINGS

CALENDAR

Nov.

5—Metropolitan New York Section. Schwartz' Restaurant, 54 Broad St., New York City. "Surface Preparation for Organic Coatings," by A. J. Liebman, Dravo Corp., Pittsburgh.

11—Houston Section. Kelley's, 910 Texas Ave., Houston. "Haynes Corrosion Resistant Alloys and Their Application in Industry," E. D. Weisert, Haynes-Stellite Co.

18—Chicago Section. Chicago Engineers' Club, 314 S. Federal St., Chicago.

18—Cleveland Section. "Bacterial Corrosion," R. C. Weast, Case Institute of Technology, Cleveland.

25—Southwestern Ohio. Shullers Restaurant, Reading, Ohio. "The Corrosion Resistant Properties of Copper and Its Alloys," by W. A. Tracy, American Brass Co.

Dec.

9—Houston Section. Kelley's Restaurant, Houston.

10—Greater Boston Section. (Tentative) H. P. Meissner, Massachusetts Institute of Technology, speaker.

12—Philadelphia Section. Poor Richard Club, 1319 Locust, Philadelphia. "Recent Trends in Stainless Steels and Other High Alloys," Walter A. Luce, The Duriron Co.

Liebman Will Talk at New York November 5

"Surface Preparation for Organic Coatings" by A. J. Liebman of the Dravo Corp., Pittsburgh, Penn., was the talk scheduled for the Metropolitan New York Section, November 5 meeting.

"Corrosion Protection of Natural Gas Mains in New York" by F. E. Kulman of Consolidated Edison Co., New York, was the principal talk of the September meeting held in Manhattan. Mr. Kulman described the causes of underground corrosion and the mitigative measures adopted by the five gas companies receiving the gas in New York.

During construction of the 50-mile radial main in the New York area, the coating, the insulating joints, and the magnesium anode protection installations were carefully tested. Surveys after construction indicated a practically corrosion-free main.

In another address to the September group, John McCreary of Transco discussed some unusual construction problems encountered in the vicinity of Philadelphia, the New Jersey meadows and the Hudson River submarine crossing.

Names of candidates for 1953 section officers will be submitted by the nominating committee. Nominations from the floor will be accepted also.

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Inquiries concerning advertising in Corrosion should be addressed to Central Office NACE, 1061 M & M Building, Houston 2, Texas.

CONTRACTS FOR CHICAGO CONFERENCE EXHIBIT SPACE

A descriptive brochure and a copy of the contract and specifications containing an application for exhibit space for the Ninth Annual Exhibition of the National Association of Corrosion Engineers was mailed Oct. 20 to known prospects of record October 15. The exhibit will be held in connection with the annual conference at Hotel Sherman, Chicago, March 16-20, 1953.

- **Anyone interested in this exhibit who has not received the information listed above is invited to write promptly to NATIONAL ASSOCIATION OF CORROSION ENGINEERS, 1061 M & M Building, Houston 2, Texas, attention of A. B. Campbell, Executive Secretary, requesting copies.**

Pittsburgh Section—

Scheduled for the October meeting of the Pittsburgh Section was the talk, "Designing To Prevent Corrosion From the Metallurgical Standpoint," by H. E. Trout, Jr., Metallurgical Engineering Department, University of Pittsburgh.

George A. Mills

George Arthur Mills, a member of NACE since 1944, and retired superintendent of the Central Power & Light Co. power plants in Corpus Christi, died in a Dixon, Illinois, hospital recently. Mr. Mills helped organize the Corpus Christi Section and was a member of the Section until he retired in 1951 when he moved to Illinois. He retained his NACE membership after retirement. Mr. Mills' first experience with corrosion problems was in 1913 in protection of underground pipe systems from stray currents of street railway and interurban systems. For some years he continued his work with stray underground currents, working in Waterloo, Iowa and Winnipeg, Canada.

In later years, Mr. Mills worked on corrosion problems around power plants, water plants and gas and water distribution systems. He came to Corpus Christi from Dallas in 1939. While in Corpus Christi, he designed the Nueces Bay Power Plant constructed in 1939, and also designed the additions to the plant made later.

Mr. Mills was a Fellow in the American Institute of Electrical Engineers, and a charter member of the South Texas Engineers Club. He also belonged to the Rotary Club.

He was born in Buchanan County, Iowa, July 5, 1885 and graduated from Iowa State College at Ames in 1909 with a bachelor of science degree in electrical engineering. Surviving are his widow, Clara and one son, Charles William Mills.

Harold L. Gaidry

Harold Langdon Gaidry, principal gas engineer for New Orleans Public Service, Inc., and a member of NACE since 1944 died last September in a New Orleans hospital. He was 54 years old.

Mr. Gaidry, a native of Louisiana, attended Tulane University in New Orleans, where he received his bachelor of science degree in engineering in 1923. He joined Public Service in 1924. He was a member of the American Gas Association and held various offices in the organization. He also was a member of the American Public Works Association, the American Water Works Association, the United States Chamber of Commerce, the New Orleans Chamber of Commerce, and the Young Men's Business Club of New Orleans. He is survived by his widow, the former Mary Easton Buck, his mother, one sister and one brother.

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In each December issue of Corrosion there is published a tabular cross-indexed reference to all technical material published in the preceding 12 months. This table includes a chronological list of papers and authors, by page numbers and an alphabetical list of authors.

Philadelphia Panel—

(Continued From Page 2)

immersed magnesium anodes when the environment is changed to moist vapors.

Which metals and alloys are most and least susceptible to concentration cell corrosion; use of liquid neoprene coatings on industrial equipment; the phenomena of polarization without cathodic-anodic action; welding 321 stainless steel in fabrication processes; also Type 347 stainless steel and the use of titanium as a stabilizer and how it acts; welding in helium and argon atmospheres;

Use of a cathodic protection system on a ship's underwater body and its effects on the surface protected; oil base coatings, and vinyl coatings;

Installation of an impervious preassembled chlorinated hydrocarbon envelope between brick and concrete in a container to hold nitric acid; apparent accelerated corrosion observations with the use of chromate inhibitors on metals; selection of the best system to protect steel against mildly corrosive water; explanation of limits of stopping pitting of Type 316 stainless steel pipe when exposed to chloride water; factors entering into cathodic corrosion of lead covered electric cable; use of neoprene coated lead sheeted cables.

The scope of the program was so great that the trend of the discussions quickly changed on each question from the wide, general all inclusive range to a specific case.

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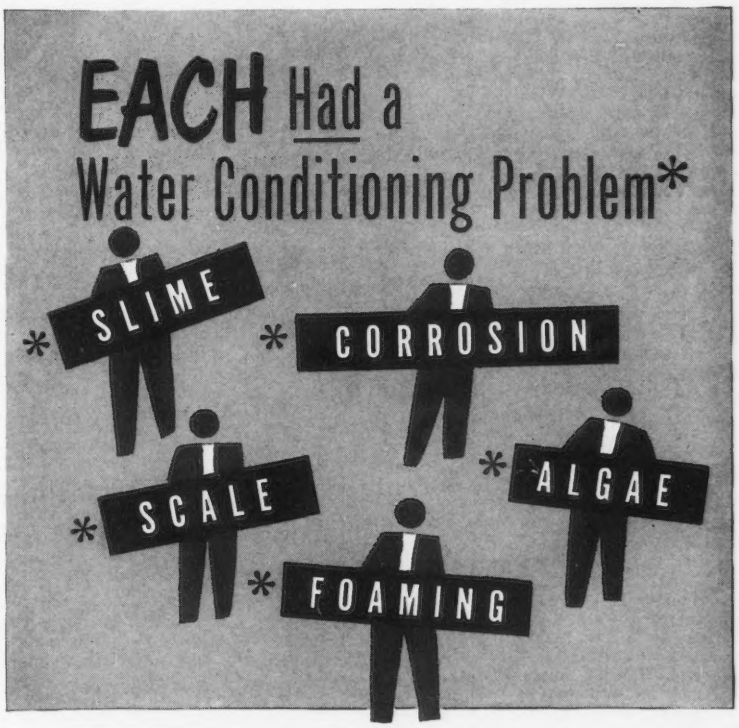
Reprints of technical material printed in Corrosion are not made except on special order. A limited number of reprints of especially interesting material is made on occasion.



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Chicago Section Sees Inco Film, Names New Committee for 1953

Chicago Section members and guests saw the 70-minute International Nickel Co. color film "Corrosion in Action" at the September meeting. The program was preceded by a fellowship hour and a steak dinner. Ladies were invited to the meeting and most of the guests were wives of members.

The third Tuesday of each month was selected as the meeting dates for the section. Harry M. Zimmerman of the B. F. Goodrich Co., speaking on "Vinyl Resins and Rigid Polyvinyl Chloride" will be the speaker for October.

The following committees were selected for the 1952-53 term:

Arrangements: F. J. Holsinger, Corn Products Refining Co., Argo, Ill., chairman.

Hospitality: R. L. Lothringer, Sinclair Research Labs., Harvey, Ill., chairman; R. G. Rydell, National Aluminate Corp., Chicago, L. W. Peterson, Swift & Co., Chicago; A. H. Seymour, Corn Products Refining Co., Argo, Ill. and S. Serbula, Jr., Allied Industrial Supply Co., Chicago, members.

Host: R. H. Weisert, Sales Engineering Inc., Chicago, Ill., chairman; Len Rissiter, Industrial Coatings Corp., Chicago and F. P. MacDonald, Electro Rust Proofing Corp., Chicago, members.

Membership: R. A. Prosser, Duriron Inc., Chicago, chairman; F. W. Pfohl, Armour & Co., Chicago and E. H. Kinelski, Pullman-Standard Car Mfg. Co., Hammond, Ind., members.

Publicity: composed of R. B. Janota, Swift & Co., Chicago and W. L. Kinney, Standard Oil Co., Chicago.

Program: R. W. Flournoy, Corn Products Refining Co., Chemical Div., Argo, Ill., chairman.

Chicago Section's programs for five meetings through May, 1953 have been announced as follows:

October 21—Vinyl Resins and Rigid Polyvinyl Chloride by Harry M. Zimmerman, B. F. Goodrich Co.

November 18—Corrosion Resistant Equipment, by Walter Luce, The Duriron Co.

January 20—Stainless Steel Corrosion Failures by Barclay Morrison, Carpenter Steel Co.

February 17—Round Table Discussion on protective coatings.

May 19—Round table discussion, general corrosion.

Detroit Holds Question And Answer Session

"Corrosion In Action," a film produced by the International Nickel Co., and a question and answer period monitored by J. M. Bostwick of the Steel Sales Co. on the subject of various alloys which could be utilized to mitigate corrosion in industry were highlights of the first fall meet of the Detroit Section.

The meeting was held in September at the Engineering Society of Detroit, Backham Memorial Building. Fifteen members and 32 guests attended.

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Many, but not all, back issues of Corrosion are available for sale.

Nine Meetings Are Set by Cleveland

Cleveland Section's 1952-53 program includes nine meetings through May, the first being a corrosion alloy forum scheduled September 25.

The program follows:

Sept. 25—Corrosion and Alloy Forum, Williams and Co., Inc.

Oct. 21—Field Trip—full day plant visit to Republic Steel Corp., Massillion and Canton Stainless Steel—production from blast furnaces to cold rolling.

Nov. 18—"Bacterial Corrosion," Dr. R. C. Weast, Asst. Prof. Chemistry, Case Institute of Technology, Cleveland, Ohio.

Dec. 16—"The Application of Corrosion Preventives by Army Ordnance," D. W. Wright, Cleveland Ordnance District.

Jan. 13—Joint Meeting with Cleveland Electro-Chemical Society — "Recent Developments in Corrosion Laboratory Techniques."

Feb. 17—"Corrosion of Iron and Steel," Dr. R. B. Hoxeng, Research Lab. U. S. Steel Corp., Pittsburgh.

March 17—"The Use of Plastics in Corrosive Environments," speaker to be selected.

Apr. 21—"Water Treatment for Corrosive Prevention," speaker to be selected.

May 19—Plant tour and "refreshments" Loisys Brewing Co., Cleveland, Ohio.

All meetings are to be held at the Cleveland Engineering Society unless indicated otherwise. Coffee talks or short films are planned for the lecture meetings.

Uhlig Addresses St. Louis Section September 8

H. H. Uhlig, Massachusetts Institute of Technology, spoke before a large meeting of Greater St. Louis Section September 8 on "The Making of a Corrosion Engineer." There were 63 members and guests present, some attending the Washington University corrosion short course then in session.

Atlanta Section Meets To Develop New Ideas

First meeting of the newly formed Atlanta Section was scheduled October 20 at the Harris Restaurant, Atlanta, Ga. A get-acquainted session and general discussion to develop ideas and to explore possibilities for future meetings were on the agenda. A movie was scheduled for presentation at the meeting. The Atlanta Section is the first separate section organized in the South East NACE Region and now has 18 members.

Petrocelli Named

J. V. Petrocelli, Patent Button Co., Waterbury, Conn., has accepted chairmanship of the Corrosion Principles Symposium for the NACE 1953 conference at Chicago.

Cardwell Talk Features Houston Section Meeting

Houston Section members at a September 9 meeting heard a talk, "Microstructure and the Corrodibility of Steel in Inhibited HCl Solutions," by Dr. P. H. Cardwell, main speaker of the evening. Dr. Cardwell is chief chemist for Dowell Inc., Tulsa, Okla.

He revealed that in a study of the corrodibility of steels it was found that the degree of annealing as measured by the resolution of the pearlite, the grain size and the presence of the Widmanstaten structure has considerable influence on the corrosion rate of steels. Two acid inhibitors were examined in order to investigate materials which could satisfactorily be used to protect different grain structure steels during industrial applications of inhibited hydrochloric acid solutions.

Dr. J. M. Woodburn, head of the department of mechanical engineering, Rice Institute, was the coffee speaker. His topic was "The Individual's Future in Engineering."

Scheduled for the Houston Section meetings is as follows:

Oct. 14—V. B. Volkening, Dow Chemical Co.; Hulon Crawford, Humble Oil and Refining Co. Joint meeting with Houston Paint and Varnish Club. "Problems of the Paint User and Paint Manufacturer." Followed by panel discussion and round table.

Nov. 11—E. D. Weisert, Haynes Stellite Co., "Haynes Corrosion Resistant Alloys and Their Application in Industry."

Dec. 9—To Be Announced.

Jan. 13—A. W. Tracy, American Brass Co., "Condenser Tube Alloys."

Feb. 10—S. E. Doughty, Carpenter Steel Co., "Stress Corrosion Cracking of Stainless Steels."

March 3—Frank LaQue, International Nickel Co. Joint meeting with the American Society for Metals.

April 14—University Night.

May 12—Founder's Night Program.

All of the meetings except March 3 will be held at Kelley's. March 3 meeting to be held at the Ben Milam Hotel.

Talks on Coatings Are Heard at Dallas

North Texas Section, NACE held a joint meeting with the Dallas Paint, Varnish & Production Club at the El Phenix Cafe, Oak Cliff, Dallas, Oct. 6. The speakers were Ben Grimes, Dallas City Water Works; Bill Thornton, Atlantic Refining Co.; Otto K. Sieplein, Sherwin-Williams Paint Co.; and Clarence H. Dragert, C. H. Dragert Co., all of Dallas. Sixty were present.

The speeches were brief and each talk was followed by a discussion by NACE members and members of the Dallas Paint, Varnish & Production Club. It was the first joint meeting of the two groups, and it provided an opportunity for users and manufacturers of protective coatings and paints to discuss their problems.

Wickenden Is Elected

T. H. Wickenden of The International Nickel Co., Inc., has been elected a member of the Welding Research Council of the Engineering Foundation for a three-year term beginning October 1.

Tulsa Invites Region To Meet There in '53

Appointment of a nominating committee for election of Tulsa Section 1953 officers, announcement of a technical course to be held at A & M College, a decision to invite the South Central Region meeting to Tulsa for the 1953 meeting and the appointment of a committee to present the invitation, were some of the highlights of the September 22 Tulsa Section meeting.

"Coal Tar Coating Specifications in Relation to the Manufacturer and Consumer" was the topic of the speaker, Norman Shideler, Pittsburgh Coke & Chemical Co., Pittsburgh, Penn. A discussion period followed the talk.

Section Chairman J. N. Hunter, Jr., appointed L. A. Hugh chairman of the nominating committee with Fred Pyeatt and F. McNulty as members. Election Tellers were: T. D. Williamson, Jr., chairman; Don B. Good and E. J. Liggett, members.

Selected on an invitation committee to invite the holding of the South Central Region meeting in 1953 in Tulsa were: T. D. Williamson, Jr., chairman; and F. N. Hieronymus and William Hutchison, members.

Announcement was also made concerning pipe coating tests scheduled to be held near Bartlesville in October.

Definite date for the December meeting was not set.

Recent Changes in TP Committees Listed

Recent changes of officials in the Technical Practices Committee are as follows:

TP-1A—Pacific Coast. A. H. Tomkins, Jr., resigned. Vice-chairman, J. J. Browne, General Petroleum Corp., Box 726, Wilmington, Cal.

TP-1C—Vice-chairman added: H. E. Greenwell, Atlantic Refining Co., Dallas.

TP-1F—Now chairman, F. A. Prange, Phillips Petroleum Co., Bartlesville, Okla.

TP-4—Minimum Current Requirements for Cathodic Protection. J. M. Pearson, Sun Oil Co., resigned.

TP-5A—Vice-chairman added, W. A. Luce, Duriron Co., Dayton, Ohio.

TP-5B—W. W. Sweet, Colgate-Palmolive-Peet Co., resigned as chairman.

TP-5D—F. L. Whitney, Monsanto Chemical Co., resigned as chairman.

TP-6, PACIFIC—Changed to West Coast Division. Chairman: L. L. Whiteneck, Long Beach Harbor Dept., Long Beach, Cal.

TP-6B—Vice-chairman added, L. L. Sline, Sline Industrial Painters, Houston.

TP-6D on Pipe Line Coatings and TP-6F on Protective Coatings in the Food Industry both dropped.

TP-6G—Vice-chairman added, L. R. Whiting, Bakelite Corp., New York.

TP-6I on Metallic Coatings and TP-6J on Standards, both dropped.

TP-15 on Corrosion Control in the Transportation Industries. Added vice-chairman, G. M. Magee, Association of American Railroads, Chicago.

TP-18A—Vice-chairman added, J. H. Hunter, Jr., Service Pipe Line Co., Tulsa.

TP-18B—Vice-chairman added, Raymond Hadley, Susquehanna Pipe Line Co., Philadelphia.

Cooling Water Problems Discussed at Port Arthur

"Use of Surface-Active Agents in Cooling-Tower Water Treatment," by W. F. Oxford, Jr., Sun Oil Co., Beaumont was the main address for the September meeting of the Sabine-Neches Section. The meeting was held in the Goodhue Hotel, Port Arthur, Tex. It was decided to hold the next meeting October 30 at Lake Charles, La.

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The 12-issue subscription price of Corrosion to non-members of NACE is now $9. The single copy price to non-members is $1.

Sulfide Stress Reprints Are Now Available

Reprint copies on the Symposium on Sulfide Stress Corrosion, consisting of four papers on this subject presented at the Galveston, 1952 meeting of NACE and one reprint paper from the Canadian Mining and Metallurgical Bulletin, are available. The 36-page reprint is available from National Association of Corrosion Engineers, 1061 M & M Bldg., Houston 2, Texas, at $1 per single copy or 50 cents per copy for five or more copies to one address.

It was published in the October issue of Corrosion and has been designated Publication 52-3.

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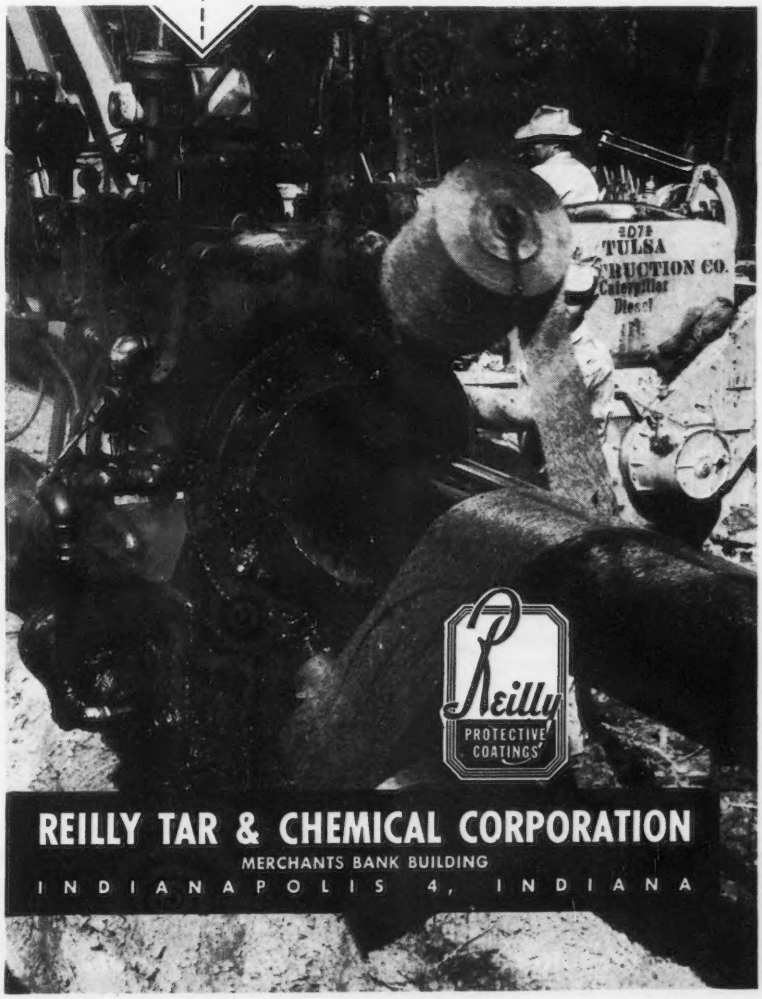

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Nationally Known Speakers Will Participate In Western Region Meeting November 20-21

Members of the Western Region will meet at the Los Angeles Biltmore November 20-21 for the Western Region Conference. Eight speakers will give addresses on a variety of technical subjects and entertainment for members and their ladies has been arranged.

W. M. Schilling, chairman, Western Region, said the program will include the showing of a film, "Corrosion In Action" produced by the International Nickel Co.; a fellowship hour and dinner and entertainment in the Biltmore Ballroom the evening of the 20th.

Eight of the speakers who will address the conference are: Dr. Norman Hackerman, University of Texas; Dr. Pierre Van Rysselberghe, University of Oregon; C. G. Munger, Amercoat Corp., South Gate, Cal.; E. H. Tandy, Standard Oil Co. of Cal., El Segundo, Cal.; E. N. Frisius, Magna Products, Inc., Santa Fe Springs, Cal.; I. E. Boberg, Chicago Bridge & Iron Co., Chicago; H. A. Humble, Dow Chemical Co., Midland, Mich. and L. L. Whiteneck, Long Beach Harbor Dept., Long Beach, Cal.

A. B. Campbell, executive secretary of NACE will be present to provide information on the operation of Central Office NACE. Registration fee for the meetings is $4.00.

In addition to the Regional officers, the following are serving on the Conference Committee: Guy Corfield, program; John Brown, arrangements; Austin S. Joy, M. L. Michand, and R. P. Howell, publicity; Robert H. Kerr, registration and Paul Krikscus, entertainment.

Bulow Heard on Tube Alloys at San Francisco

The San Francisco Bay Area Section heard C. L. Bulow, corrosion metallurgist of the Bridgeport Brass Co. speak on "Corrosion Testing of Condenser Tube Alloys." Mr. Bulow discussed the corrosion of copper base alloys and the effect of varying the concentration of alloying elements. Particular emphasis was placed on corrosion problems encountered in condenser tubes. The meeting was held at the Alouette Restaurant, San Francisco, Cal.

Inhibitors Is Wachter's Topic at Los Angeles

"The Use of Inhibitors for Corrosion Control in the Petroleum and Chemical Industries" by Aaron Wachter, Shell Development Co., Emery, Calif. was the talk scheduled for the September meeting of the Los Angeles Section.

Mechanisms of inhibitor action and an explanation of how inhibitors work were his topics. This included discussion of electrochemical theory, adsorption and film theories, passivation, the role of oxygen in inhibition, localized attack caused by inhibitors, action of inhibitors in bimetallic systems and classification of inhibitors.

In addition, information on the characteristics of important inhibitors used industrially and on new developments in corrosion inhibitors was to be given. A discussion of the selection of inhibitors for specific applications, the principles guiding initial selection and the methods for determining their suitability was to follow. To be included also was a discussion of important and interesting examples of the practical applications of inhibitors in petroleum production, refining and pipe lines and in chemical process industries.

The meeting was held September 17 in Roger Young Auditorium.

Committee Directory Copies Are Available

Copies of the 1952 Committee Directory of the National Association of Corrosion Engineers, published August, 1952, designated Publication No. 52-2 are available for sale. The price to NACE members is $1 and to non-members $2 per copy postpaid. The directory includes the names and addresses of all members of technical and standing committees of the association as of the publication date.

•

The 1954 Conference and Exhibition of the National Association of Corrosion Engineers will be held March 15-19 at Kansas City, Mo.

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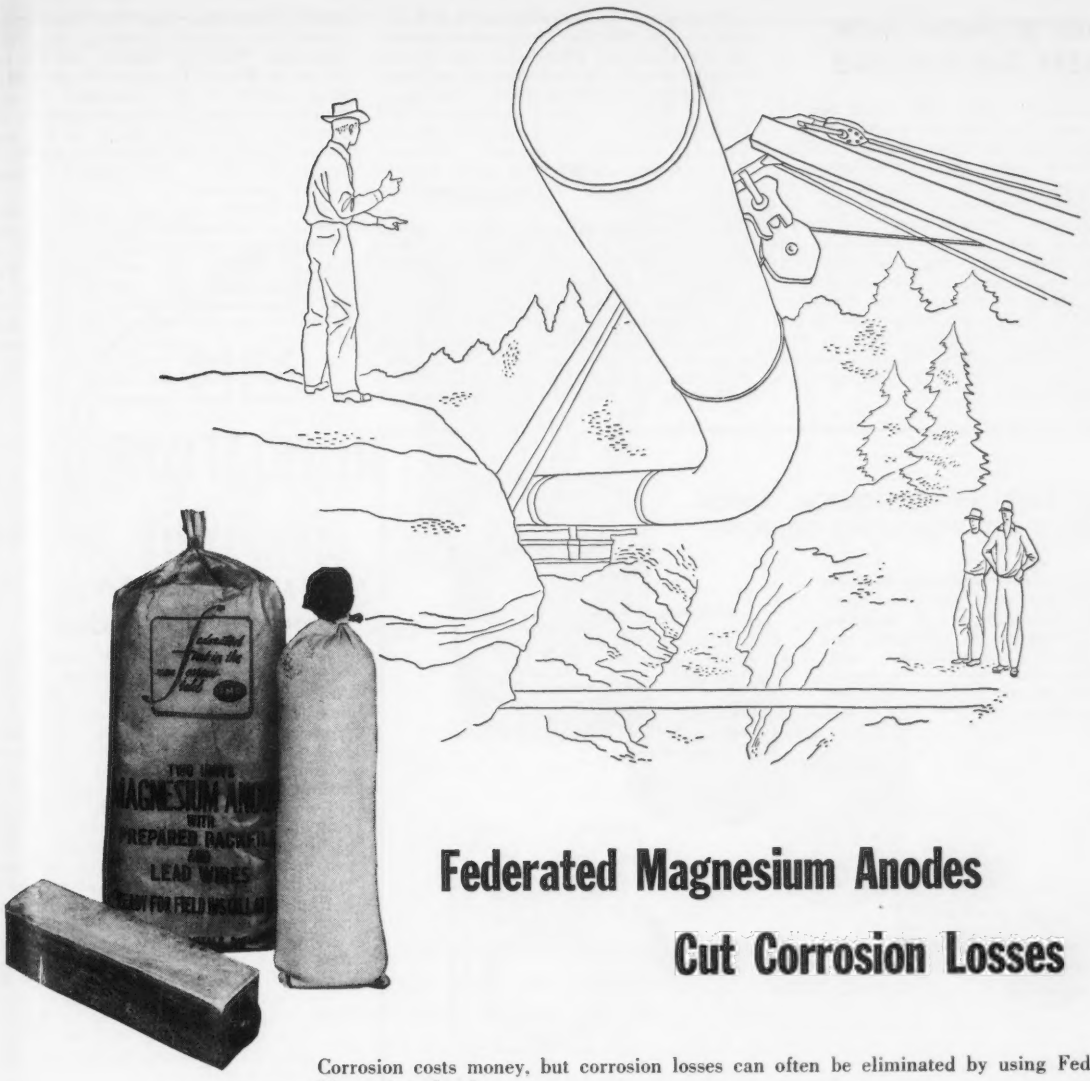

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Awards at Metal Show By ASM Are Revealed

An annual seminar, the Gold Medal Award and the Research Medal Award were highlights planned for the 34th National Metal Congress and Exposition of the American Society for Metals held in Philadelphia in October. Theme for the meeting was "Metal Keeps the Peace."

"Modern Research Techniques in Physical Metallurgy" was the subject in morning and afternoon sessions of the seminar held Saturday and Sunday. Oct. 18-19. Fourteen papers were to be presented by outstanding men in the metals field. Throughout the week, morning afternoon and evening technical sessions were held.

Winner of the Gold Medal award, established in 1943 "to recognize outstanding metallurgical knowledge and exceptional ability in the diagnosis and solution of diversified metallurgical problems," went to Robert F. Mehl, chairman of the Metallurgical Advisory Board of the National Academy of Sciences, National Research Council and head of the department of metallurgy at Carnegie Institute of Technology.

Cleo F. Craig, president of the American Telephone and Telegraph Co., was unanimously recommended by the award committee to receive the Medal for Advancement of Research. Mr. Craig has been for many years a director of the Bell Telephone Laboratories and the great progress made by the laboratories was given as the reason for his selection.

Meeting concurrently with the National Metal Exposition was the Society for Non-Destructive Testing, Inc., The American Welding Society and the Institute of Metals Division of the AIME. Most papers to be presented by outstanding industrial and management engineering executives were in the airframe, electrical, metallurgical, chemical, heavy equipment and non-destructive testing industries.

The Metals Section of the Special Libraries Association planned a regional meeting with papers and discussions of mutual interest to metallurgists and technical librarians. Various types of automatic machines being developed for literature handling were to be described. Availability of government research reports, problems of foreign language literature and the functions of the technical library were planned as topics of talks and discussions.

The new defense metal, titanium and IB alloys was the subject of an all day symposium under the chairmanship of M. A. Hunter, dean, Rensselaer Polytechnic Institute. Also in conjunction with the exposition, the seventh Metallographic Exhibit was held.

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A separate condensed subject index lists all technical symposia. Cost per copy: ASTM members $4.75; others, $6.

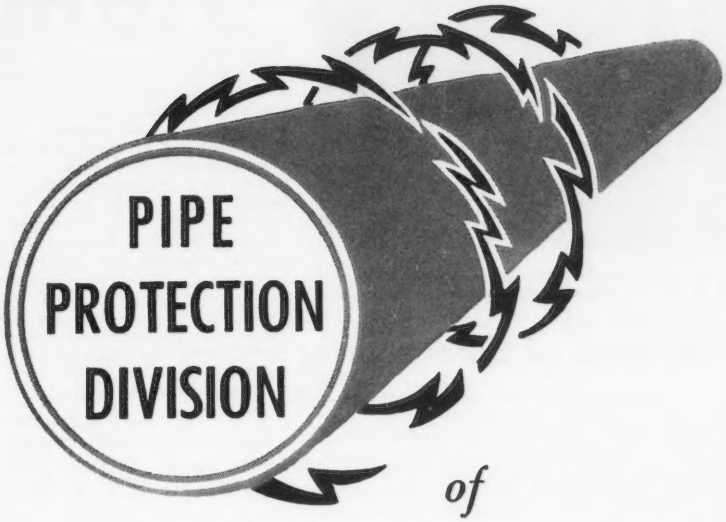
The society concurrently has issued a Bibliography and Abstracts on Electrical Contacts covering 1835 to 1952, a 226-page, cloth covered book designated Publication 56-F.

Crerar Library Issues New Abstract Service

"Crerar Metals Abstracts," a new service offered by the John Crerar Library, 86 East Randolph St., Chicago, Ill., is an abstract service of scientific articles on the "minor metals." The service costs $50.00 for 12 issues. The metals covered in the abstract in the August issue included titanium, zirconium, hafnium and the rare earth metals. Five of the abstracts in this issue, most of them on titanium, were of interest to the corrosion engineers.

St. Louis Meeting Hears Robinson on Galvanic Corrosion

An electrochemical analysis of the corrosion reaction, corrosion cell behavior and current-potential relationships at a corroding metal surface were described by Harold A. Robinson of Dow Chemical Company at St. Louis October 15. He addressed 27 section members on the subject "Galvanic Corrosion and Cathodic Protection.



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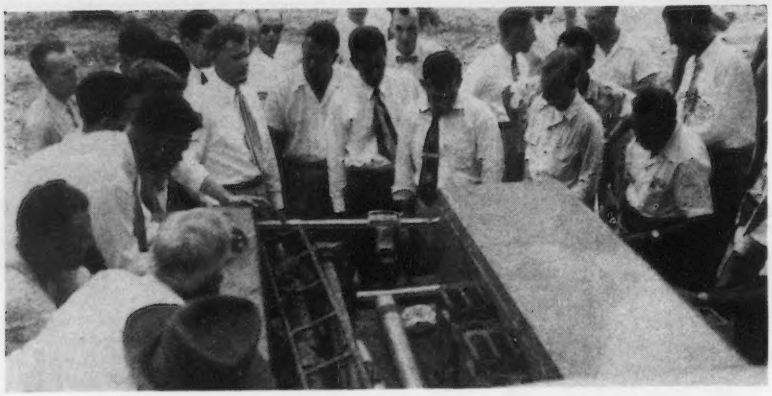
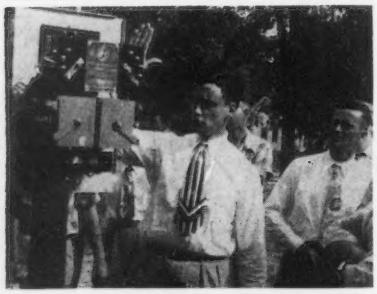
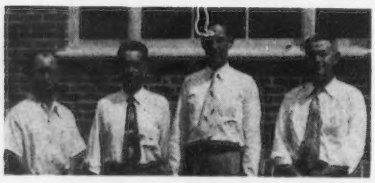


DOWN-THE-HOLE calibration of corroded oil well tubing is demonstrated during the Shreveport Section Corrosion Short Course September 18-19 by Roy Warren, Tuboscope Co., Shreveport.

Field Demonstrations Featured at Shreveport



RECTIFIER INSTALLATION for cathodic protection is explained during Shreveport Section Short Course September 18-19 by A. W. Peabody, Ebasco Services, N. Y.



SHREVEPORT SHORT COURSE committee in charge of arrangements for the September 18-19 sessions at Centenary College, left to right: Robert Bullock, Interstate Oil Pipe Line Co.; W. A. Broome, Arkansas-Louisiana Gas Co.; C. W. Evans, United Gas Pipe Line Co. Not present when photograph was taken, Pat Miller, Texas Eastern Transmission Corp.

Demonstrations of actual techniques used in making installations of cathodic protection systems highlighted the third short course given by Shreveport Section NACE September 18 and 19. There were 103 registrants attending the 10 technical sessions at the auditorium and science building of Centenary College, Shreveport and the technical demonstrations on the campus.

Eight instructors handled the ten sessions. While short courses previously given by Shreveport section have been oriented to the interests of the corrosion worker not classed as a corrosion engineer, the 1952 course was designed so the material was of interest equally to field technicians and the experienced engineer.

Section officials were expressive of their thanks for the cooperation of Centenary College in providing its facilities.

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NACE sells subscriptions on a calendar year basis of McBee punch cards on which are printed abstracts of corrosion literature published in more than 500 periodicals at home and abroad. More than 2000 cards are issued annually. They are pre-indexed according to the punch card index system by topics, periodical in which published, first and second authors, and year.

Tennessee University Offers Corrosion Course

The University of Tennessee at Knoxville is offering an undergraduate course in corrosion in the Engineering College which covers study of the nature, mechanism and present theories of corrosion and its mitigation. Emphasis is placed on forms of corrosion and their effect on the mechanical properties, a knowledge of which is essential for design work.

Also covered are corrosion by atmosphere, aqueous media, soils, hot gases, molten salts and liquid metals, the latter being a fairly recent addition to corrosion technology resulting from the use of nuclear energy.

50 New Members Gained by NACE At St. Louis Course

Fifty non-members of the National Association of Corrosion Engineers attending the Washington University, St. Louis short course on corrosion September 8-12 have applied for membership in the association. There were registered 122 persons, of whom 54 were non-members of NACE. Twenty-three states were represented and persons attended from Canada, Colombia, Honolulu.

Interest among the registrants expressed itself in spirited discussions and several requests that additional evening meetings be held for further discussions. It also was suggested that motion pictures or pictorial data on the uses of corrosion testing instruments be included, and the suggestion the opportunity to see laboratory scale exhibits in the evening was received favorably.

High Level Attendance

Significant was the attendance by level of supervision. There were present two company presidents, three vice-presidents or directors, two managers and eleven plant or department superintendents. These 18 constituted better than 10 percent of the attendance and evidenced the growing interest in the management echelon in corrosion matters.

University professors expressed pleased astonishment when requests were made for additional night-time sessions. One evening session was organized and held by pipe line people September 10. The university faculty was impressed by the consistent use of visual aids by the lecturers.

A trip through the Anheuser-Busch bottling plant was attended by 65 or 70 persons and it was reported some excellent singing voices were found among the visitors.

Credit for the smooth functioning of the course was given to Dr. Reals, dean of the University College and to Dr. Brandenburg, assistant dean by F. L. Whitney, Jr., North Central Region NACE Director.

The university's news report on the session interjected a comment from the school's janitor that the group was the cleanest he had ever had in the building.

(Continued on Page 12)

CLASSROOM SESSION during the Washington University, St. Louis Short Course on Corrosion held in September. The course had 122 registered.

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API Sessions Include Corrosion Meetings

Meetings of interest to corrosion workers scheduled during the 32nd Annual meeting of the American Petroleum Institute at Chicago November 10-13 are:

November 10—9 a.m. Subcommittee on Corrosion. Chairman, E. Q. Camp.

November 9—2 p.m. and November 10—9 a.m. Joint meeting: H. H. Anderson presiding. Committee on Pipe Line Technology, H. H. Anderson, chairman; Subcommittee on External Corrosion, D. C. Glass, chairman; Subcommittee on Products Pipe Line Technology, J. W. DeGroot, chairman; Subcommittee on Internal Corrosion of Crude Oil Pipe Lines and Tanks, R. A. Brannon, chairman; Subcommittee on Lease Tank Practices, R. Charles Nicholson, chairman; Subcommittee on Pipe-Line Hydraulics, John D. Peterson, chairman; Subcommittee on Pipe-Line Construction Practices, J. C. Stirling, chairman.

Welding Society Will Convene in Houston

The American Welding Society has announced its plans for conducting a National Spring Technical Meeting at the Shamrock Hotel in Houston, June 16-19, 1953.

The technical paper program will include papers and symposia on welding and allied subjects of national and regional aspect and technical treatise subjects of interest to the specialized industry of the Southwest, the aircraft, the oil, chemical, shipbuilding and others.

Some Lecturers Are Selected for Corrosion Course in California

Some lecturers for the University of California, Berkeley Corrosion Short Course February 2-6 have been named. The course is being given by the university's departments of mechanical engineering, mineral technology and chemical engineering in cooperation with the National Association of Corrosion Engineers.

A chronological outline of the course was published in CORROSION, October, Page 4, News Section. Listed below are the names of lecturers and their subjects given by the university:

Opening of the meeting: Baldwin M. Woods, vice-president, University extension.

Introduction to Study of Corrosion and Fundamentals, M. G. Fontana, Ohio State University.

Ferrous Metals, V. V. Kendall, National Tube Division, U. S. Steel Co.

Non-Ferrous Metals, W. Z. Friend, International Nickel Co., Inc.

Special Alloys, M. G. Fontana.

Organic Protective Coatings, G. W. Seagren, Stoner-Mudge, Inc., Mellon Institute.

Cathodic Protection Principles, H. A. Robinson, Dow Chemical Company.

Chairman of the presentation "Special Topics in Corrosion" will be Mark F. Adams, Washington State Institute of Technology.

Corrosion Testing and Evaluation, Frank L. Whitney, Jr., Monsanto Chemical Co.

Design of Equipment from the Corrosion Standpoint, Ward Pratt, Worthington Corp.

Metals at High Temperature—Oxidation and Structural Stability, James G. Kerr, C. F. Braun and Co.

The Role of Corrosion Engineer in Industry, Vance N. Jenkins, Union Oil Company.

50 New Members—

(Continued From Page 10)

Following statistics were compiled from registration records:

TABLE I

Geographical Distribution

Alabama	2	New Jersey	1
Arkansas	1	New Mexico	1
California	1	New York	7
Illinois	13	Ohio	2
Indiana	2	Oklahoma	4
Iowa	1	Pennsylvania	6
Kansas	3	Texas	21
Kentucky	4	West Virginia	2
Louisiana	6	Wisconsin	1
Maine	1	**Countries**	
Maryland	1	Canada	3
Michigan	4	Colombia, South America	1
Minnesota	1	Hawaii	1
Missouri	32		

TABLE II

Industrial Distribution

Chemical	33	Protective Coatings	5
Metal Supply & Fabrication	20	Air-Army-Navy Forces	4
Petroleum & Refining	18	Consulting Engineers	2
Utilities, Gas & Electric	12	Instruments	2
Pipe Line	6	Railroad	1
Metal Mining & Products	6	Automotive	1
		Pharmaceutical	1
		Food Stuffs	1

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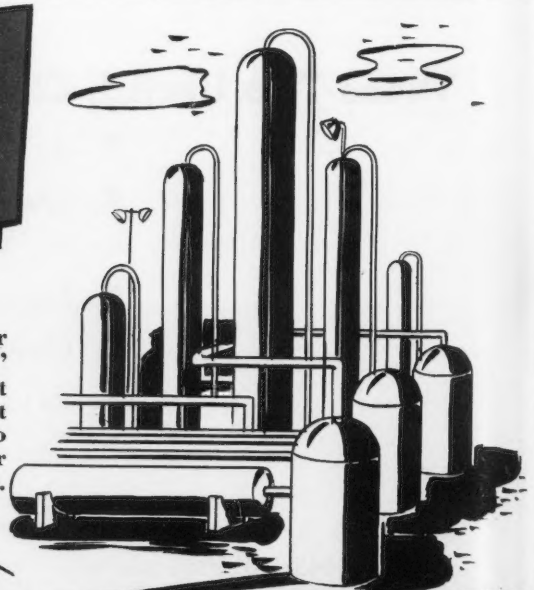

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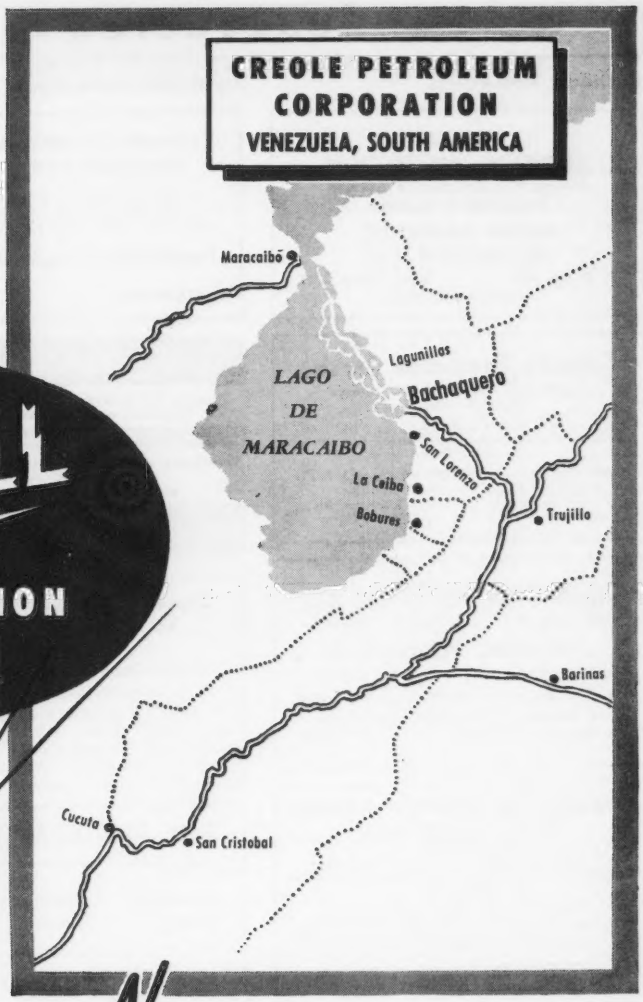

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The 1953 Conference and Exhibition of the National Association of Corrosion Engineers will be held March 16-20 with headquarters at the Sherman Hotel, Chicago.

Committee Praised for Highly Successful South Central Region Meeting at N. O.

High praise for committeemen responsible for the outstandingly successful South Central Region meeting at New Orleans October 1-3 was voiced by T. F. P. Kelly, regional director. "Cliff Barr, general arrangements chairman and John Loeffler, technical program chairman and their co-workers are to be congratulated on their efforts. I feel sure NACE members recognize and appreciate the efforts of these committeemen in making possible such a worthwhile and enjoyable meeting," Mr. Kelly said.

"The meeting reminded many old-timers of the national meeting held in Kansas City in 1946," Mr. Kelly reminisced.

Registration of 570, of which 484 were men and 86 women guests by far exceeded that of any previous South Central meeting. Registration at New Orleans was almost equal to registration at the national meeting in 1946, and total registration at New Orleans was in excess of that at Kansas City.

High Level Attendance

The presence of many top level management representatives of the larger oil and gas pipe line companies indicated a continuing and growing interest on their part in the activities of NACE, Mr. Kelly asserted. Attendance of management representatives probably was due in part to the special emphasis placed on management problems regarding corrosion in the technical program.

The technical program consisted of 21 items divided among four symposia, all relating to petroleum production and transportation. A special feature was five addresses on the relationship between the corrosion mitigation work of NACE and principal organizations in the petroleum field also engaged in corrosion control activities.

Preprints of five of the technical papers were prepared and distributed, and discussions following the presentation of papers were collected.

New Officers Nominated

New officers for the region were nominated as follows: H. E. Waldrip, formerly vice-chairman, was nominated to become chairman; T. F. Moffatt, Jr., secretary, was nominated to become vice-chairman. Clifford L. Barr, of New Orleans, general chairman of the 1952 regional meeting, was nominated to become secretary-treasurer, while John E. Loeffler of Houston, technical program chairman for the meeting was nominated to become assistant secretary-treasurer. Derk E. Holstein of Houston was nominated as regional director. Election of officers will be by letter ballot of region membership.

Among the best attended events during the meeting was the all-day Pipe Line Forum, while the TP-1H committee meeting, presented at a special open session, drew a large number of interested spectators.

Other technical committees meeting were TP-1 on Corrosion of Oil and Gas Well Equipment, TP-18A on Internal Sour Crude Corrosion of Pipe Lines and Tanks and TP-6G on Surface Preparation for Organic Coatings. This latter committee, with A. J. Liebman of Dravo Corp., chairman, approved for publication its report on "Surface Preparation of Steel for Organic Coatings." After review by the Chairman of the Technical Practices Committee T. S. Zajac, the report will be published.

Social Events Held

Social events included a "Get Reacquainted" cocktail party October 1; a luncheon and general business meeting October 2 and the annual Fellowship Hour and Banquet October 3. Many registrants remained in New Orleans for the October 4 Santa Clara-Tulane University football game. A special program was arranged for ladies attending.

Field trips to Rheem Manufacturing Co. plant and to Kaiser Aluminum Co. plant were made available.

Painter Named ASTM Executive Secretary

The American Society for Testing Materials has elected Robert J. Painter as executive secretary of the society and Raymond E. Hess as associate executive secretary and editor-in-chief, according to an announcement by Harold L. Maxwell, president of the society. Mr. Painter was elected on recommendation of a special committee which had been appointed to recommend a successor to the late C. L. Warwick, long-time executive secretary who died suddenly last April.

Mr. Painter has been treasurer and assistant secretary and Mr. Hess technical secretary and editor of the society which has 10,000 members.

Wellman Is Advanced

Case Institute of Technology has appointed Gerald S. Wellman as vice-president in charge of development.

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Chicago Technical Program Chronological Schedule Is Set Tentatively by Schmidt

A tentative chronological schedule of symposia has been proposed for the Ninth Annual NACE Conference and Exhibit at Chicago March 16-20, 1953, by H. W. Schmidt, Technical Program Chairman. The principal difference from arrangements in previous years is scheduling of the forum discussions on underground and general corrosion problems on Thursday rather than Friday, the last day of the conference. Also new is the scheduling of three educational lectures on corrosion fundamentals on successive afternoons beginning at 4:15 p. m. This latter feature is being presented for the first time.

There remained to be named a chairman for the Pipe Line Protective Coatings Symposium and a chairman to head the underground corrosion problems round table.

Mr. Schmidt's schedule was as follows:

Tuesday, March 17

9 to 11 am—Corrosion Principles Symposium.
11 to 12:30 am—Annual business meeting.
2 to 4:15 pm—Corrosion by Fresh and Salt Water and Refinery Industry symposia.
4:15 to 5:15 pm—Educational Lecture No. 1.

Wednesday, March 18

9 to 11:30 am—Pipe Line Protective Coatings and Power and Communication Industry Symposia.
2 to 4:15 pm—Oil and Gas Production Industry and Corrosion at Elevated Temperatures Symposia.
4:15 to 5:15 pm—Educational Lecture No. 2.

Thursday, March 19

9 to 11:30 am—Cathodic Protection Symposium and General Corrosion Problems Round Table.
2 to 4:15 pm—Underground Corrosion Problems Round Table and Chemical Industry Symposium.
4:15 to 5:15 pm—Educational Lecture No. 3.

Friday, March 20

9 to 11:30 am—Protective coatings and Chemical Industry Symposia.

Scheme of Educational Lectures Is Outlined

Electrochemical principles, cathodic protection, galvanic corrosion, factors controlling corrosion rates, diffusion, chemical conversion coatings and organic coatings as barriers are among the topics to be covered in the three Educational Lectures to be given daily Tuesday through Thursday, March 17-19 inclusive during the 1953 Chicago NACE meeting. In general the lectures will stress the fundamental aspects of these subjects and the third day will relate the limitations of the electrochemical approach.

R. B. Hoxeng of United States Steel Co., chairman and R. C. West, Case Institute of Technology, co-chairman, are in charge of the series.

The three lectures are to be as follows:

First Lecture—Electrochemical principles and a discussion of cathodic protection.

Second Lecture—Over-all corrosion processes, with emphasis on factors controlling corrosion rates and distribution of corrosion and a discussion of the role of diffusion to and through barrier films, such as corrosion products films and chemical conversion coatings.

Third Lecture—Organic coatings as barriers and applications and limitations of the electrochemical approach.

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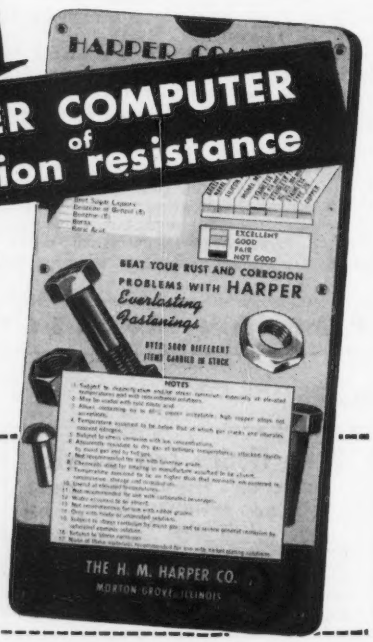

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Fall South East Region Meeting Set November 6 at Atlanta

The Peachtree Hotel, Atlanta, is the scheduled scene of the Fall South East Region meeting November 6. The all-day meeting will be followed by a dinner and a round table discussion.

H. C. Van Nouhuys, secretary-treasurer, announced the following schedule: 9 to 9:45 a.m., registration; 9:45 a.m., business meeting; 10:45 a.m., "Cathodic Protection of Co-Axial Cable from Miami to Key West," T. J. Maitland, American Telephone and Telegraph Co., New York; 12 noon, lunch.

1:30 p.m., film, "Corrosion in Action," International Nickel Co.; 3 p.m., recess; 3:15 p.m., "Clean-Up of New Products Pipe Lines," Ivy M. Parker, Plantation Pipe Line Co., Atlanta; 4:15 p.m., "Some Factors to Be Considered in Application of Certain Austenitic Stainless Steels," Frank Whitney, Monsanto Chemical Co., Anniston, Ala.; 5:30 p.m., Fellowship Hour; 6:30 p.m., dinner; 8 p.m., round table with panel of program speakers.

Enamel Institute Has Several Corrosion Papers

Among the papers presented at the "Shop Practice Forum" of the Porcelain Enamel Institute, held September 10-12 at the University of Illinois, Urbana, were four which touched on the corrosion resistance properties of enamel.

"Alkali Resistance of Enamels," gave results of a test by Westinghouse Corp. The tests were conducted because of government restrictions on the use of cobalt in enamels and the firm was attempting to find what effect restriction of use of cobalt would have in the alkali resistance of the spinner tubs in the automatic clothes washer made by Westinghouse. It was found that a cobalt-free base enamel covered with an enamel top coat containing cobalt wore better than enamels where both the base coat and the top coat contained cobalt.

"One Hundred and One New Uses for Porcelain Enamel," by Charles P. Lohman, Pemco Corp. lists among other uses, the enamel protective coatings in industries, and the author states that "In the range of farm equipment alone there is an enormous potential market." The electrical field with switch boxes, junction boxes, transformer cases provides a good market; use of enamel in dryer-liners, industrial roofing and siding for small buildings, cooling towers for air conditioning systems, smoke house panels in meat processing plants was also given as a market for enamel.

"The Use of Porcelain Enamel on Aluminum," by Everan C. Woodland, Bureau of Ships, Navy Department gives some facts on how enameled aluminum stands up when used as bulkheads. In the opinion of an officer of the Naval Transport "U.S.S. Wakefield," porcelain enamel bulkheads saved the ship when a fire broke out which stripped the vessel of its entire superstructure. Use of aluminum made it possible to build the liner "S.S. United States" big and yet light in weight, the author states. Several other uses of enamel on aluminum or steel are suggested.

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There are many reasons why Bitumastic Enamels are the best barrier against corrosion. Here's an important one: through the years, Bitumastic Enamels keep moisture away from pipe-line surfaces, and that prevents corrosion. *Ordinary* protective coatings just can't keep out moisture year after year.

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Officials of Chicago 1953 Technical Program

Some of the officials in charge of parts of the technical program at the 1953 Chicago Conference are described here. More pictures and biographies will be published as they are made available.

Corrosion Principles

J. V. Petrocelli, director of research at The Patent Button Co., Waterbury, Conn., is chairman of the Corrosion Principles Symposium. Mr. Petrocelli is principally interested in fundamentals of corrosion reactions, particularly mechanisms and kinetics of electrode processes including the mechanisms of passivity. He has done research work in polarography and electrodeposition as well as electrochemical instrumentation. He attended Wesleyan University in Connecticut, receiving his BA degree in 1934 and his MA degree in 1936. He received his PhD degree from Yale University in 1943. Mr. Petrocelli was faculty assistant at Wesleyan. He later went with The Patent Button Co. as chemist. He became laboratory director in 1939, and in 1950 was made research director for the firm.

Refinery

R. S. Treseder, supervisor with the Shell Development Co., Emeryville, Calif., is chairman of the Refinery Symposium. He is a graduate of the University of Utah with a BS degree in chemical engineering in 1938. Immediately after graduation he went with the Shell Co. He began corrosion research in 1940 and has participated in a variety of corrosion investigations in the petroleum and chemical industries. He is chairman of NACE TP-1G—Sulfide Stress Corrosion. He is also chairman of the San Francisco Bay Area Section.

Educational Lectures

Raymond B. Hoxeng was Research Associate and Professorial Lecturer at Case Institute of Technology, in charge of a research project sponsored by the AISI on the "Corrosion of Galvanized Steel Pipe by Domestic Waters." Also he was instrumental in organizing course work in corrosion and was in charge of the Corrosion Short Course sponsored jointly by Case and NACE. He is now Research Associate in charge of the Chemical Metallurgy Division at the Research and Development Laboratory of the United States Steel Company. Activities in this division include studies of the corrosion characteristics of all ferrous materials with particular emphasis on the corrosion of tin plate. Dr. Hoxeng served as Chairman of the Cleveland Section of NACE during 1950-1951 and is currently Chairman of the Publication Committee and ex-officio member of the NACE board of directors. Other professional associations include membership in American Society for Metals and Electrochemical Society (member of the Corrosion Handbook Committee of the latter society).

Robert C. Weast, professor of chemistry at Case Institute of Technology, Cleveland, Ohio, is co-chairman of the Educational Lectures for the 1953 Conference. Mr. Weast received a PhD degree in chemistry from the University of Illinois in 1943. He has been a consultant, researcher, and teacher, and has been a member of NACE since 1948. He has conducted studies of galvanic corrosion in hot water storage tanks.

Electrical and Communication

C. H. Fellows, director of the engineering laboratory and research department of the Detroit Edison Co., Detroit, Mich., is chairman of the Electrical and Communication Symposium. His primary interests are the application of chemistry to steam power plant problems, especially water treatment, corrosion, and lubrication. He is a member of the American Society for Testing Materials, American Chemical Society, Society of Automotive Engineers, Electrochemical Society, Inc., past chairman and member of the Executive Committee of the Joint Research Committee on Boiler Feedwater Studies. He is a graduate of Purdue University, school of chemical engineering. He joined the Edison Company in 1919 as a chemist in the research department.

W. D. Sanderson is Supervising Engineer in the Cable Corrosion and Loading Department for the Detroit Edison Company. His work concerns the corrosion protection of cable sheaths, pipes, and other underground structures. He furnishes load ratings of all power cables and tests for resultant temperatures. His main interests are corrosion protection and heat radiation in connection with high-voltage, pipe-type cables. He is a member of TP-16 on Electrolysis and Corrosion of Cable Sheaths.

Russell M. Lawall, corrosion engineer for the American Telephone and Telegraph Co., Cleveland, Ohio, division office, is co-chairman of the Electrical and Communication Symposium. Solving maintenance problems associated with aerial, underground and buried communication cable facilities in the Cleveland Division is Mr. Lawall's job. The division consists of the states of Indiana, Michigan and Ohio. He was vice-chairman of the North Central Region in 1951. In 1951, he was co-chairman of TP-16C Committee on "Cathodic Protection of Cable Sheaths," and this year he is chairman of the committee.

Oil and Gas

H. L. Bilhartz is chairman of the Oil and Gas Symposium. Mr. Bilhartz is chemical engineer in charge of field problems and material evaluation in the production department of the Atlantic Refining Co., Dallas, Tex. He received undergraduate training at Southwestern University and graduate training at Harvard and Massachusetts Institute of Technology. He served three years in the Navy during World War II. Mr. Bilhartz is active in committee activities of the Natural Gasoline Association of America and National Association of Corrosion Engineers. He is chairman of NACE Committee TP-1—Corrosion of Oil and Gas Well Equipment—and chairman of Committee TP-1C—Sweet Oil Well Corrosion.

(Continued on Page 20)

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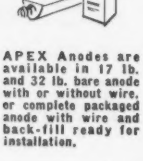

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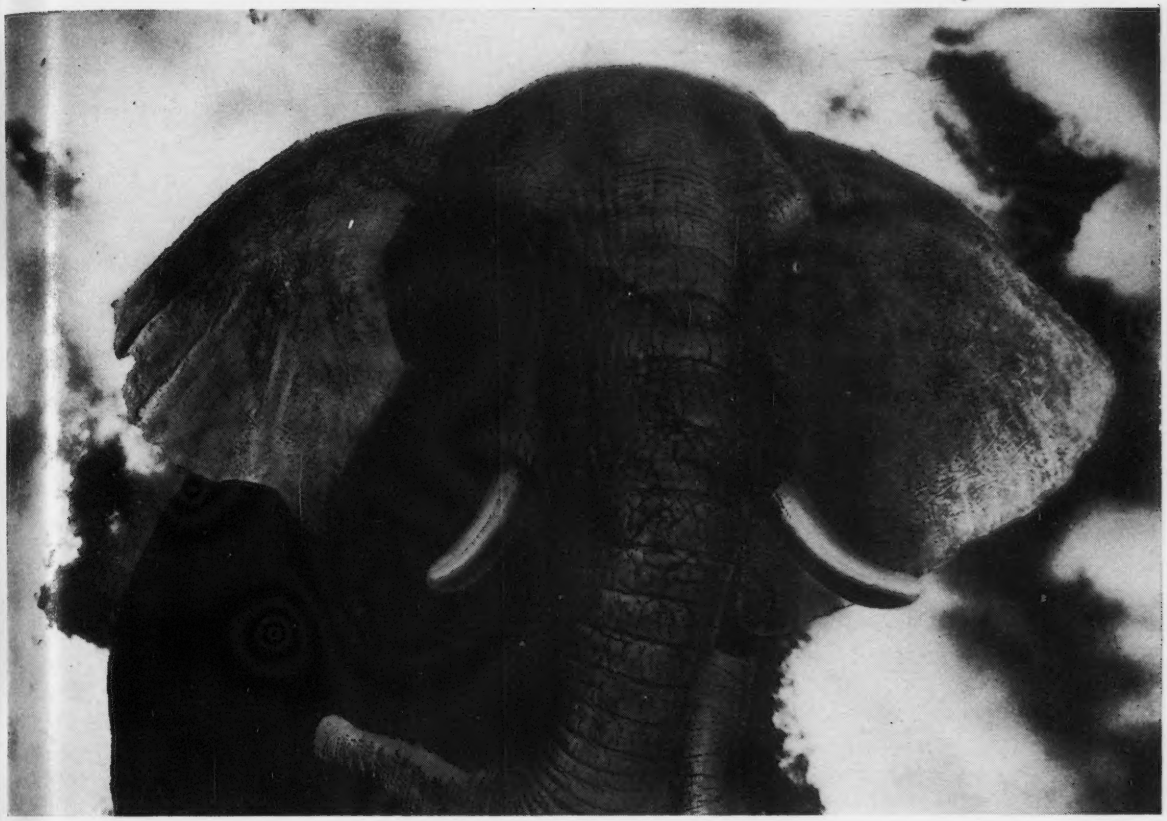

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Officials of Chicago Technical Program

(Continued From Page 18)

R. C. Buchan, Humble Oil and Refining Co., Houston, Tex., is co-chairman of the Oil and Gas Symposium. Mr. Buchan is in charge of the Chemical Engineering Section of The Humble Oil and Refining Co.'s Production Department. He has been employed in chemical work by Humble since he obtained a BS degree in chemical engineering from Texas A & M in 1930. A substantial part of his time during the last several years has been devoted to corrosion problems. He has written several API papers, including one on corrosion. He is vice-chairman of NACE Committee TP-1—Corrosion of Oil and Gas Well Equipment.

Cathodic Protection

E. P. Doremus graduated with BS in ChE from Southwestern Louisiana Institute and MS from Louisiana State University. After graduation, he served in research and development with Shell Oil Company, Houston, Texas, and as Chief Chemist and Process Engineer with J. S. Abercrombie Company, Old Ocean, Texas. From 1946 to the present, he has been managing partner of the Cathodic Protection Service, Houston. He is a member of NACE, ACS AIChE, AGA, TSCE, Alpha Chi Sigma and the Petroleum Club of Houston.

General Corrosion Roundtable

Charles E. Pogacar is chairman of the General Corrosion Roundtable. Mr. Pogacar is supervisor, engineering methods and construction materials section; and metallurgist, engineering and construction department of the Atlantic Refining Co., Philadelphia, Pa. Mr. Pogacar directs the evaluation of materials of construction as used in the petroleum industry from both the engineering and economic standpoints. He has charge of investigation of protection by use of corrosion resistant materials coatings, inhibitors and galvanic means. He is presently chairman of Committee TP-5C—Subsurface Corrosion by Alkaline Solutions.

Protective Coatings

L. L. Whiteneck is Senior Harbor Engineer for the Board of Harbor Commissioners, Long Beach, California. He is a graduate of Washington State College in Civil Engineering. His service since graduation includes eight years in the Philippine Islands. His work concerns the technical problems of harbor design and maintenance. He is interested in the corrosion mitigation of large steel piling installation in sea water and the protection of large steel surface structures in marine atmospheres. He has served as chairman and vice-chairman of the Western Region and is now coordinator of the Western Region Division of TP-6 and is also National NACE director representing the Western Region. He was co-chairman of the Protective Coatings Symposium in 1952.

N. K. Senatoroff is Chemical Engineer for the Southern Counties Gas Company of California. Following his graduation from California Institute of Technology in 1928, he entered the utility industry with the Los Angeles Gas & Electric Company. He later became affiliated with the Southern Counties Gas Company of California and has since served that company in a number of technical capacities. His work is chiefly concerned with gas processing including purification, dehydration and corrosion study and control of above and below ground installations, transmission and distribution systems of the company. Corrosion control supervision includes specifications of various protective coatings and the application of cathodic protection as a supplementary means of corrosion control. His main interest is soil corrosion control. However, his studies also include internal corrosion of gas and water lines and equipment. He has been a member of NACE TP-2 Committee, and was chairman of the Symposium on Corrosion, NACE Western Region Corrosion Conference, 1951.

Mr. Senatoroff has written numerous papers on corrosion in dehydrating towers with calcium chloride, cathodic protection of large diameter pipe lines and pipe coatings.

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The 1953 annual NACE meeting will be held in Chicago, March 16-20.

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The Inter-Society Corrosion Committee was organized to help eliminate duplicated research into corrosion matters.

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Several AIChE Papers Pertain to Corrosion

Safe, easy handling of heavy corrosive, abrasive or toxic materials was the subject of a talk delivered to the American Institute of Chemical Engineers at its national meeting in Chicago, Ill., by T. W. Matchett of the Link-Belt Co.

Two other papers, both on ion exchange were presented to members of AIChE. In one paper, Joseph Thompson, Rohm and Haas Co., Philadelphia, Pa., described a new system of ion exchange equipment for demineralizing water which would cut operating costs and size of water purification plants. It is stated that the monobed deionization process as described by Mr. Thompson has been accepted by many power engineers as the preferred method for producing a water of most satisfactory quality as a feed for extremely high pressure boilers in the steam power generation field.

The other paper on analysis of ion exchange was by Dr. C. Calmon head of the research and analytical laboratories, The Permutit Co., New York, N. Y. He explained the use of an ion exchange resin in analyses. He told how small columns or single beads of these ion exchangers may be used to determine ionic concentrations of boiler waters, the degree of hardness in a water supply, the end point in water softening runs, the pH of acid and other procedures involving electrolytes. He stated that a single bead, two-hundredths of an inch in diameter has been used for about 15 consecutive tests. Placed in water, the dry resin particles swell 25 to 50 times their original size. When brought into contact with electrolytes, the volume of the particles changes. The amount of change depends on the concentration and the type of ions. This change can be measured easily and quickly, it was stated.

The American Institute of Chemical Engineers has scheduled the following meetings:

December 7-10, 1952, Cleveland, Ohio, annual meeting. March 8-11, 1953, Biloxi, Miss. April 26-29, 1953, Toronto, Canada (joint meeting with the Chemical Institute of Canada). Sept. 13-16, 1953, San Francisco, Cal. Dec. 13-16, 1953, St. Louis, Mo., annual meeting; March 8-10, 1954, Washington, D. C. May, 1954, Springfield, Mass. September 12-16, 1954, Glenwood Springs, Col. Dec. 5-8, 1954, New York, N. Y., annual meeting.

ASM Tests Aimed at Improved Pipe Lines

Ductility, yield strength and fracture tests are being conducted at Pennsylvania State College in an effort to develop better pipe lines according to the American Society for Metals. Some of the test stresses are exerted from interiors of the sample to find how pipe lines can be made of lighter, more easily transportable material and keep from bursting or bulging.

Three scientists from the department of engineering mechanics of the Pennsylvania school were to report on their findings at the American Society for Metals annual convention. Joseph Marin, professor of engineering and two aides, L. W. Hu and J. F. Hamburg conducted the experiments.

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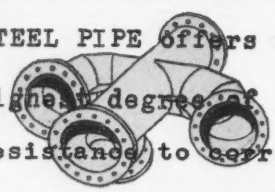

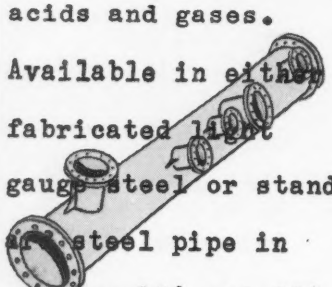

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BOOK REVIEWS

Electrochemical Data. By B. E. Conway, The Chester Beatty Research Institute, London. 374 pages plus xx. 6 x 9, cloth. The Elsevier Press, Inc., 402 Lovett Blvd., Houston. Per Copy $8.75.

Data are accumulated which are not generally available in other handbooks. Author begins with a treatment of universal constants and ratios and some conversion factors vital to workers in the electrochemical field. A group of tables and data gives general information on physical properties which are relevant to the electrochemistry of solids and solutions. Molecular and ionic interaction in the liquid phase are elaborated and data given on activity coefficients, osmotic coefficients, hydration, salting out and salting in of strong electrolytes in aqueous and non-aqueous solutions and mixtures.

One chapter of tables deals with transport in solutions of strong electrolytes, electrolytic migration and diffusion.

Several pages of data are given on dissociation constants, solubilities and buffer solutions including ionic equilibria, electric double layer at interfaces, transport of colloids and melts. Final chapters deal with electrode processes, principally those which are reversible and with parameters of electrode kinetics. There is a topical index.

ASM Teaching Awards

Two thousand dollars was awarded to each of three professors selected by an awards committee of the American Society for Metals for doing the best jobs of teaching in metallurgical engineering during 1951-52.

The three professors and their schools are: Arthur A. Burr, associate professor, department of metallurgy, Rensselaer Polytechnic Institute, Troy, N. Y.; Joseph W. Spretnak, associate professor, department of metallurgical engineering, Ohio State University, Columbus; Robert D. Stout, professor, department of metallurgy, Lehigh University, Bethlehem, Pa.

Winner of the Dr. Albert Sauveur Achievement Award was Dr. John Chipman, head of the department of metallurgy, Massachusetts Institute of Technology. The award was established in 1934 by the American Society for Metals in honor of the late Dr. Albert Sauveur, Harvard professor and widely known as the dean of American Metallurgists. Dr. Chipman is said to be one of the country's top authorities on process metallurgy and is highly regarded for his ability in teaching graduate and post-graduate students.

Bjorksten Foundation

A non-profit foundation for scientific research in pure and applied science has been formed by the Bjorksten Research Laboratories, Madison, Wis. "The Bjorksten Research Foundation has been formed to explore and develop findings which do not have an immediate commercial application, but which, rather, strike at fundamentals," said Dr. Johan Bjorksten, president of the research firm. The secondary aim of the foundation will be to develop for commercial use, the scientific advances developed. To finance the foundation four classes of membership have been set up. The admission fee paid by each member will be considered as a "loan" and will be repaid on a regular basis from the foundation's net earnings.

NACE

New Members and Changes of Address

• This list is published principally for use by NACE Regional and Sectional officers in keeping their mailing lists up to date.

NEW MEMBERS

(Additions through September 27, 1952)

ARIZONA

LOESH, EARL J., Hughes Aircraft Co., P. O. Box 2225, Tuscon, Arizona.
MORELL, FORREST L., Republic Supply Co. of Calif., 405 E. Roosevelt, Phoenix, Arizona.

CALIFORNIA

BEAL, SAMUEL E., Douglas Aircraft Co., Inc., 3000 Ocean Park Blvd., Santa Monica, Cal.
CAMPBELL, HARRY D., Franco Western Oil Co., 3120 18th Street, Bakersfield, Cal.
BIBEE, A. A., Douglas Aircraft Co., Inc., 827 Lapham St., El Segundo, Cal.
FINDL, EUGENE, Southern California Gas Co., Box 3249, Terminal Annex, Los Angeles, Cal.
FISCHER, PAUL W., Union Oil Co. of California, Brea Research Center, Brea, Cal.
HARRIS, PHILEMON G., Airesearch Mfg. Co., 9851 Sepulveda Blvd., Los Angeles 45, Cal.
HIMEL, GEORGE, Mission Appliance Corp., Hyde Park Station, Los Angeles 43, Cal.
HUNTER, JOHN C., Shell Oil Co., Box 728, Wilmington, Cal.
MILLER, JAMES D., Aerojet Engineering Corp., Azusa, Cal.
NELSON, E. RAYMOND, Western Gulf Oil Co., Box 471, Bakersfield, Cal.
ROJO, JOHN, Hughes Aircraft Co., Florence St. & Teale St., Culver, Cal.
SANDERSON, AUSTIN O., Standard Oil Co. of Calif., El Segundo Refinery, El Segundo, Cal.
TROIANI, FRANCIS, Mare Island Naval Shipyard, Code 254, Bldg. 521, Vallejo, Cal.
USAB, MARTIN A., Reflin Company, P. O. Box 452, Gardena, Cal.
VALLES, ANTHONY G., Northrop Aircraft, Inc., Crenshaw & Broadway, Hawthorne, Cal.

COLORADO

PAULMAN, WILLIAM H., Julius Hyman & Co., Rocky Mountain Arsenal, Denver, Col.

DELAWARE

BRADY, JAMES M., 1217 Newport Pike, Woodcrest, Wilmington 177, Delaware.

DISTRICT OF COLUMBIA

PIERSON, HUGH O., Metallurgical Res. & Dev. Co., Inc., Barr Bldg., Washington 6, D. C.

FLORIDA

ALEXANDER, HADSELL E., Dozier & Gay Paint Co., P. O. Box 3176, Station F., Jacksonville, Florida.

ILLINOIS

JANKE, PETER L., 2823 N. 75th Ave., Elmwood Park 35, Illinois.
JANOTA, RUDOLPH B., Swift & Co., Research Laboratories, Chicago 9, Illinois.
SCHUENEMAN, HARRY H., JR., Industrial Coatings Corp., 3227 South Shields Ave., Chicago, Ill.

INDIANA

BOWERS, WILLARD R., 1118 Laurel Street, Elkhart, Indiana.

LOUISIANA

BOOKSH, JAMES H., JR., United Gas Corp., 323 Broad St., Lake Charles, La.
HARVEY, FRANK H., 3115 Wyoming St., Baton Rouge, La.
HOPPER, RALPH V., Kaiser Aluminum & Chemical Corp., P. O. Box 1031, Baton Rouge, La.
KERBY, CHARLES L., P. O. Box 85, Broussard, La.

MASSACHUSETTS

GRANT, ROBERT L., Metropolitan Transit Authority, 536 Harrison Ave., Boston, Mass.
SMITH, EBEN O., Dist. Public Works Office, First Naval Dist., 495 Summer, Boston 10, Mass.

MICHIGAN

GUINTHER, PAUL J., JR., Koppers Co., Inc., 1312 United Artists Bldg., Detroit, Mich.
SCOLLAY, KENNETH L., 13503 Monrose St., Detroit 27, Mich.
SENNETT, WALTER M., Parker Rust Proof Co., 2177 E. Milwaukee, Detroit, Mich.

(Continued on Page 24)

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New Members—

(Continued From Page 22)

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NOLAN, HERBERT A., Beck & Corbitt Co., 1230 North Main, St. Louis, Mo.
SHUTT, GEORGE T., Atlas Mineral Products, 1110 Brentwood Blvd., St. Louis 17, Mo.

NEW JERSEY

GOLUB, LILLIAN LENA, Colgate-Palmolive-Peet Co., 105 Hudson St., Jersey City, New Jersey.
LEEDOM, LAURIE M., 27 Fairway, Bloomfield, New Jersey.
POSS, FRED J., E. I. du Pont de Nemours, c/o New York Shipbuilding Corp., Camden, New Jersey.
SHAFFER, PERCY C., The Cooper Alloy Foundry Co., Bloy & Ramsey, Hillside, New Jersey.

NEW YORK

BOYD, GEORGE E., Koppers Co., Inc., 350 Fifth Avenue, New York, New York.
LEHMANN, JOSEPH A., Ebasco Services, Inc., 2 Rector St., New York 6, New York.
LOCKE, NORMAN W., Reilly Tar & Chemical Corp., 500 Fifth Ave., New York 36, New York.
MORSE, MURRAY E., JR., THE LOG—Miller Freeman Publications, 370 Lexington Ave., New York, New York.
SINCLAIR, EDWARD L., A. M. Byers Co., 30 Rockefeller Plaza, New York 20, New York.
THURBER, WALTER P., Water Service Laboratories, Inc., 423 W. 126th St., New York, New York.

OHIO

ACKERMANN, ROBERT W., American Tel. & Tel. Co., 138 East Court St., Cincinnati, Ohio.
TRIVISON LEE M., Ohio Bell Telephone Co., 820 West Superior, Cleveland, Ohio.
WILLGING, JAMES F., Ohio State Univ. Res. Found. Room 208, Eng. Exp. Station, Columbus, Ohio.

PENNSYLVANIA

BINGER, WAYNE W., Research Laboratories, Aluminum Co. of American, New Kensington, Pa.
SICKMAN, EDISON C., 2404 Highland St., Allentown, Pa.

SOUTH CAROLINA

JAHNZ, HUGO R. C., JR., Southern Corp., P. O. Box 810, Charleston, South Carolina.

TEXAS

BASKETT, FOREST, Rheem Manufacturing Co., P. O. Box 2102, Houston, Texas.
BLACK, KENNETH P., JR., Stanolind Oil & Gas Co., Box 3092, Houston, Texas.
BLOOMQUIST, CHARLES T., Corrostops Company, P. O. Box 3049, Houston, Texas.
BYARS, HARRY G., 1719 Congress Ave., Austin, Texas.
CARROLL, DAVID R., Humble Pipe Line Co., Corrosion Lab., Rt. 7, Box 1400, Houston, Texas.
COLLINS, ROBERT RAY, 1735 Robert St., Beaumont, Texas.
DEHN, GEORGE L. C., Magnaflux Corp., P. O. Box 7104,, Dallas, Texas.
FISHER, B. M., 1218 W. 4th St., Freeport, Texas.
FOLZENLOGEN, M. DAVID, Atlantic Refining Co., Box 2819, Dallas, Texas.
HANSON, HARRY R., Humble Pipe Line Co., P. O. Box 2220, Houston, Texas.
HIBLER, HOWARD M., Lone Star Gas Co., 908-12 Monroe, Fort Worth, Texas.
HOLEFKA, THEODORE, Farley Company, 558 M & M Bldg., Houston, Texas.
JARED, JOHN B., JR., American Petroleum Co., 1414 Petroleum Bldg., Houston 2, Texas.
KAPLAN, MONTE, Atlantic Refining Co., P. O. Box 2819, Dallas, Texas.
KUHLMAN, JOHN L., 3295 Maplewood Lane, Beaumont, Texas.
LANDERS, CHARLES R., Service Pipe Line Co., 1820 Fair Bldg., Fort Worth, Texas.
LANDERS, JAMES E., Southern Methodist University, Box 304, Dallas, Texas.
LAYMAN, EDWARD, Diamond Alkali Co., P. O. Box 686, Pasadena, Texas.
LIGON, JOHN R., Sinclair Pipe Line Co., 901 Fair Bldg., Fort Worth, Texas.
LONCARIC, RADO, Atlantic Refining Co., P. O. Box 2819, Dallas, Texas.
MUSGROVE, JOE D., The Dow Chemical Co., Freeport, Texas.
PARSONS, RALPH H., Diamond Alkali Co., P. O. Box 686, Pasadena, Texas.
PATTERSON, HARVEY E., 1604 Kelly Terrace, Arlington, Texas.
POSTLE, DOUGLAS F., Texas Construction Material Co., 1919 Travis, Houston, Texas.
RANSOM, ROBERT G., Tennessee Gas Transmission Co., P. O. Box 2511, Houston, Texas.
RETZLOFF, A. F., Humble Oil & Refining Co., P. O. Box 2180, Houston, Texas.
ROSS, EARL H., The Parkersburg Rig & Reel Co., 449 Esperson Bldg., Houston, Texas.
SHEARON, KERVIN B., Brance-Krachy Co., Inc., P. O. Box 1724, Houston, Texas.
SHUGART, BROCK, Pacific Valves Inc., 1102 Sterling Bldg., Houston, Texas.
SLEDGE, B. L., Rice Institute, Box 322, West Hall, Houston, Texas.
SULLENDER, MAURICE C., Diamond Alkali Co., P. O. Box 686, Pasadena, Texas.
THORNTON, BRYAN W., El Paso Natural Gas Co., Elec. & Comm. Dept. Bassett Tower, El Paso, Texas.

VIRGINIA

DICKINSON, NANCYE RUTH, Dept. of Defense, Engineer Research & Dev. Labs., Bldg. 318, Fort Belvoir, Virginia.

WASHINGTON

LACY, CECIL C., Kaiser Aluminum & Chemical Corp., Box 1451, Spokane, Washington.
DE PAGTER, HENRY, Badger Meter Manufacturing Co., 2371 No. 30th St., Milwaukee 45, Wisconsin.
MARTZ, MARVIN E., Badger Meter Mfg. Co., 2371 N. 30th St., Milwaukee, Wis.
RAMSEY, PAUL W., A. O. Smith Corporation, 3533 N. 27th St., Milwaukee, Wis.

FOREIGN

BRANDER, WILLIAM G., Northwestern Utilities Ltd., 10124—104th St., Edmonton, Alberta, Canada.
BURKHOLDER, JOHN C., Powertronic Equipment Limited, 50 Bermondsey Road. Toronto 13, Ontario, Canada.
CLARKE, PHILIP A., Northwestern Utilities Ltd., 10124—104th St., Edmonton, Alberta, Canada.
COLLIER, DAVID B., Northwestern Utilities Ltd., 10124—104th St., Edmonton, Alberta, Canada.
COLLINGS, THOMAS A., MacMillan & Bloedel Ltd., Harmac Pulp Div., Drawer 18, Nanaimo, B. C., Canada.
CRAIGHEAD, WILLIAM A., Industrial Coatings Ltd., 1920 Main St., Vancouver, B. C. Canada.
GARCIA, ANTONIO BLANCO, La Electricidad De Caracas, Marron a Pelota 8, Caracas, D. F., Venezuela.
GREENWOOD, W. BRIAN, MacMillan & Bloedel Ltd., Pulp Div., Drawer 18, Nanaimo, B. C. Canada.
HENCHER, HARRY A., H. L. Blachford, Ltd., 977 Aqueduct St., Montreal 3, Quebec, Canada.
LOCKWOOD, ROBERT H., Corrosion Service Limited, 77 York St., Toronto, Ontario, Canada.
MAKEPEACE, CHARLES E., Page-Hersey Tubes, Ltd., Welland, Ontario, Canada.
NOBLE, JOHN A., 22 College St., Toronto 2, Ontario, Canada.

(Continued on Page 25)

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New Members—

(Continued From Page 24)

OGG, ALBERT M., Page-Hersey Tubes, Ltd., 100 Church St., Toronto, Ontario, Canada.
RUDDOCK, WILLIAM M., 160 Guelph Street, Acton, Ontario, Canada.
SKINNER, RALPH B., Canadian Equipment Sales & Service Co. Ltd., 7310—99th St., Edmonton, Alberta, Canada.
STODALKA, ALLAN A., Canadian West. Nat. Gas Co. Ltd., 140 6 Ave. W., Calgary, Alberta, Canada.
YATES, HAVELOCK H., Redpath Library, McGill University, 3459 McTavish St., Montreal 2, PQ, Canada.

CHANGES OF ADDRESS

(Old Address Follows New in Parenthesis)

CALIFORNIA

DROBY, HENRY S., Pabco Products Inc., Central Engineering Dept., Emeryville 8, Cal. (Electrolysis Dept., Pacific Gas & Electric Co., 4245 Hollis St.)
GIESER, RALPH, Rheem Manufacturing Co., 12009 East Washington Blvd., Whittier, Cal. (4361 Firestone Blvd., South Gate, Cal.)
KEELING, HARRY J., Southern Counties Gas Co. of Calif., P. O. Box 2736, Terminal Annex, Los Angeles 54, Cal., (810 South Flower)
NOSS, OSCAR F., JR., 1222 East 1st St., Long Beach 2, Cal. (2512 Knoxville Ave.)
NOSS, OSCAR F., c/o of Noss, Jr., 2512 Knoxville Ave., Long Beach, Cal. (Fitzgibbons Boiler Company, Inc., 101 Park Ave., New York, N. Y.)
SENATOROFF, N. K., Southern Counties Gas Co. of Calif., P. O. Box 2736 Terminal Annex, Los Angeles 54, Cal. (810 S. Flower St.)
SHERMAN, CHARLES H., The Sheral Co., 3605 Southwood Ave., San Mateo, Cal. (The C. P. Hall Co., 2510 First National Tower, Akron, Ohio.
STEFFAN, ROBERT F., Corrosion Eng. Sec., Los Angeles Dept. of Water & Power, 410 Ducommon St., Los Angeles, Cal. (Corrosion).
TALLEY, ROYAL N., Southern Counties Gas Co. of Calif., P. O. Box 2736 Terminal Annex, Los Angeles 54, Cal. (810 South Flower)
WATERS, F. O., San Diego City Water Dept., Div. of Eng., Room 702 Civic Center Bldg., San Diego 1, Cal. (Southern California Gas Co., Box 3249, Terminal Annex, Los Angeles 54, Cal.)
WOODS, ELDRO M., Southern Counties Gas Co. of Calif., P. O. Box 2736, Terminal Annex, Los Angeles 54, Cal. (810 South Flower St.)

DISTRICT OF COLUMBIA

REZNICEK, A. F., Technical Service Section, Synthetic Rubber Div., R.F.C., 811 Vermont Ave., N.W., Washington 25, D. C. (Rubber Products Engineering Co., 108 E. Fourth, Los Angeles, Cal.)

GEORGIA

HAZZARD, F. W., Haveg Corporation, 3224 Peachtree Road, N.E., Atlanta, Georgia (233 Chamberlain Bldg., Chattanooga 2, Tenn.)
VAN NOUHUYS, HERBERT C., Southeastern Pipe Line Co., P. O. Box 1737, Atlanta 1, Georgia (718 Forsyth Bldg.)

ILLINOIS

TUTTLE, LOREN W., Public Service Co. of Northern Illinois, 615 Eastern Ave., Bellwood, Ill. (72 W. Adams, Chicago, Ill.)

INDIANA

BERG, SIGVALD L., 351 N. Ohio St., Hobart, Indiana (210 East St.)

LOUISIANA

BURNS, CLAUDE A., 3805 Vanderbilt Drive, Lake Charles, La. (205)
COFFER, HAROLD R., Shell Oil Company, Box 595, Franklin, La. (Box 271, Donaldsonville)
MALONE, MAURICE O., 349 E. State St., Baton Rouge 6, La. (3986 North Blvd.)
RICHEY, VERNON T., Ace Supply Co., New Iberia, La. (Macco Sales & Service, Route 2, Box 403-C, Lafayette, La.)

MARYLAND

COLLORA, NICHOLAS A., Mathieson Chemical Corp., 820 N. Franklintown Rd., Baltimore, Maryland. (Commercial Solvents Corp., 814 So. 32nd St., Terre Haute, Indiana)
FARRAN, J. HAROLD, 411 Terrace Way, Baltimore 4, Maryland. (Maplewood Apts., Apt. B-3, 914 Belgian Ave.)

MASSACHUSETTS

KELLER, WAYNE H., Suite 22, 15 Fernald Dr., Cambridge 38, Mass. (Mallinckrodt Chemical Works, 65 Destrehan, St. Louis 7, Mo.)

(Continued on Page 26)

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Changes of Address—

(Continued From Page 25)

MINNESOTA

CARTER, GEO. M., JR., Minnesota Valley Natural Gas Co., St. Peter, Minnesota (Minneapolis Gas Light Co., 8th and Marquette, Minneapolis)

MISSOURI

FELDMAN, KARL T., Platte Pipe Line Co., 106 W. 14th St., 12th Floor, Kansas City 5, Mo. (P. O. Box 460, Independence, Kansas)

NEVADA

DODGEN, JAMES E., U. S. Naval Ammunition Depot, Hawthorne, Nevada (2108 Belvedere Dr. No. 2, Silver Springs, Maryland)

NEW JERSEY

CLEMENT, ALBERT J., Allied Chemical & Dye Corp., Morristown, New Jersey (Ebasco Services, Inc., 2 Rector St., New York)

DULANEY, ROBERT, 807 Chestnut Ave., Woodbury, New Jersey (The Philadelphia Gas Works Co., 1800 N. 9th St., Philadelphia)

EASTMAN, DOUGLAS E., 1662 M. St., West Belmar, New Jersey (Jersey Central Power & Light Co., 100 Brook St., Long Branch, N. J.)

MACCORKLE, DANIEL S., S. D. McCorkle Co., 1 Newark St., Hoboken, New Jersey (50 Church St., New York)

NEW YORK

WESTLAKE, ROBERT L., JR., National Carbon Co., 292 Madison Ave., New York 17, New York (1226 Stephens Ave., Baton Rouge, La.)

OHIO

ANGEVINE, J. GORDON, The Ric-Wil Co., 53 Antles Ave., Barberton, Ohio (Ryder Scott Co. Petroleum Engineers, Main St., Bradford, Penn.)

BRONSTEIN, EMANUEL H., 603 Hoye Ave., Akron 20, Ohio (148 East Baird Ave., Barberton, Ohio)

SANDEL, WALTER J., R. F. D. No. 1, Glenmont, Ohio (1242 Hall Avenue, Lakewood 7, Ohio)

OKLAHOMA

AMSTUTZ, RAY W., Earlougher Engineering, P. O. Box 4096, Tulsa, Okla. (3316 East 21st)

LATHAM, WALLACE L., Box 391, Oklahoma City, Okla. (1727 N. W. 37th St.)

THIBODAUX, PAUL T., JR., O. R. Burden Construction Co., P. O. Box 5216, Tulsa, Okla. (Box 2516)

PENNSYLVANIA

BINDER, WILLIAM J., Pittsburgh Corning Corp., Box 39, Port Allegheny, Pa. (A. M. Byers Co., 1810 Clark Bldg., Pittsburgh)

CAMERON, JOSEPH A., Elliott Co., P. O. Box 800, Jeannette, Pa. (Elliott Co., only)

KELLERMANN, AUGUST C., Bryton Incorporated, Box 418, Marcus Hook, Pa. (Box 125, Elizabeth, N. J.)

MACDONALD, A. JOHN, 3510—5th Ave., Pittsburgh 13, Pa. (University of Pittsburgh, 204 De Soto Hall, Pittsburgh, Pa.)

MCGLOTHLIN, BRUCE B., JR., PVT., Batry. B, 21st F. A. BN, 5th Inf. Div. Indiantown Gap Military Res., Pa. (95 Brighton Dr., Akron, Ohio)

PEABODY, A. W., 80 N. Porter St., Waynesburg, Pa. (263 Houston Ave., Jackson 9, Miss.)

SPARKS, ROBERT E., LCDR, 423 Delaware Ave., East McKeesport, Pa. (Suite 410, Mining Exchange Bldg., Denver 2, Col.)

TRACEY, EDWARD J. J., JR., 424 West Foster Ave., State College, Pa. (1227 Old Boalsburg Rd.)

TEXAS

HINKLE, GEORGE S., JR., General Manufacturing Co. of Houston, Inc., 707 N. Drennan St., Houston 3, Texas (1616 Maury St.)

HOPWOOD, WILLIAM A., Tnemec Co., Inc., 2703 South Colonial Dr., Odessa, Texas (2719 Walnut Ave.)

LUGER, KARL E., K. E. Luger Co., 2716 Danville St., Houston 6, Texas (3618 Washington Ave.)

MUERY, SAM J., JR., Freeport Sulphur Co., P. O. Drawer "A", Freeport, Texas (Port Sulphur, La.)

PENLAND, WILLIAM R., 6424 Norway Road, Dallas, Texas (1218 San Jacinto Crt., St. Louis 10, Mo.)

STEPHENS, THOMAS O., Amercoat Corporation, 1227 Levee St., Dallas 2, Texas (1001A North Crawford, Dallas, Texas)

FOREIGN

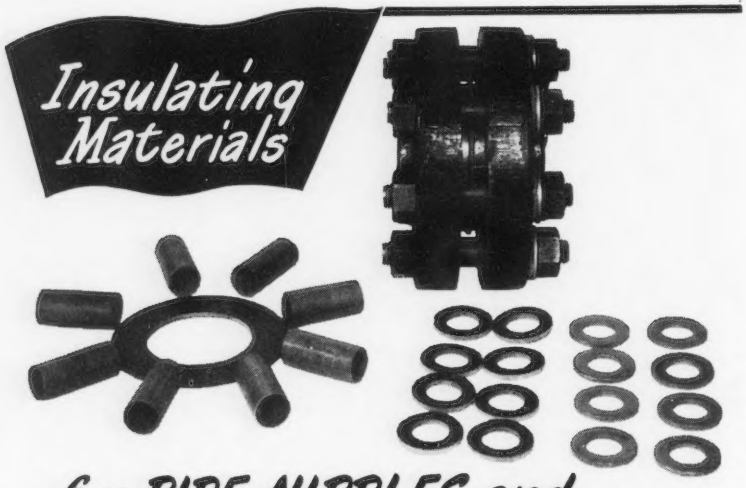
BARRIENTOS, AUGUSTO, Carrera 17, No. 49-65, Bogota, Colombia, S. A. (University of Oklahoma, Norman, Okla.)

BROWNIE, F. A., The Canadian Western Nat. Gas Co. Ltd., 140—6th Avenue W., Calgary, Alberta, Canada (215)

KELLAM, G. D., Canadian West Natural Gas, 140 6th Avenue West, Calgary, Alberta, Canada (215)

MASSUET, VICENTE, Instituto Electroquimico, S. A. Corcega 58, Barcelona, Spain (Sanz Y Massuet, S. A.)

SNYDER, B. W., Canadian Western Natural Gas Co., Ltd., 140—6th Ave. West, Calgary, Alberta, Canada (215 Sixth Avenue West)



For a period of 12 years the Nelson Electric Manufacturing Company has been furnishing Phenolic Insulating Materials for pipe nipples and the insulation of pipeline flanges. We introduced the use of thin-wall tubing sleeves for insulating the studs in standard flanges, without requiring re-drilling of the flange and providing smaller studs. We now offer flange insulation, packaged for immediate shipment on the more common sizes.

Write for new, 10-page bulletin which describes our Insulating Materials.

NELSON Electric MANUFACTURING CO.

217 N. Detroit St. TULSA, OKLAHOMA Telephone 2-5131

Hayward Describes University of Illinois Measurement Center

Prof. Harold N. Hayward of the University of Illinois described the university's measurement and instrumentation center to 100 government and other specialists attending a research conference on instrumentation. The sessions, under auspices of the American Association for the Advancement of Science, were held July 28-Aug. 1 at New London, N. H.

Professor Hayward is chairman of NACE Technical Practices Committee 1 on Instruments for Corrosion Measurement.

UNICHROME Trade Mark

News about COATINGS for METALS

Metallic . . . . . Organic . . . . . Decorative . . . . . Protective

"101" Corrosion Problems

A better lining FOR DRUMS THAT TAKE A BEATING

Lining drums is always a good idea, but even more so today, when you've steel shortages to contend with. Perhaps you've heard about how Unichrome Drum Linings are able to prevent corrosion of container and subsequent contamination of contents for many products.

But you may not have realized *how wide* a range of applications these linings really have—or how long they last. Such materials as synthetic wetting agents and detergents, alcohols, vinyl latex solutions, bleaches, solvents, acids, foods and many other products are successfully resisted by one of the various types of Unichrome Drum Linings. These save drums from the punishment of long contact with the corrosives and often permit reuse without relining.

Do *you* have a tough packaging problem? Write us about it.

Plastisol-clad Metals Last in Corrosive Service

Available metals can frequently be used where service conditions are extremely corrosive—if they're protected with a Unichrome Plastisol or Organosol Compound.

These are flexible coatings which resist chipping and abrasion . . . and when applied by dipping or spraying and baked at 350° F. build film thickness up to 3/16" with a single application. This build-up multiplies the protective qualites of these vinyl-base compounds.

Ucilon Protective Coating Systems maintain equipment against attack of many strong chemicals and corrosives*

Warnings are up. With equipment getting harder to replace, corrosion losses *have* to be cut. And they *can* be, through the aid of Ucilon Protective Coatings.

Unlike ordinary paints, systems based on Ucilon Coatings give enduring protection against a "hundred and one" strong chemicals or corrosives. By using the recommended system for your problem you get protection that lasts longer. Not only do you help keep vital equipment in continued service, but also reduce the labor and down-time expense of frequent painting.

Chemical Properties of Ucilon

Ucilon Coatings contain corrosion fighting ingredients noted for their chemical resistance—including vinyl, phenolic, chlorinated rubber or fish oil base materials. For increased durability and adhesion, wash primers, primers, and intercoats are available where individual applications require them. Used in systems of coatings, the various Ucilon Coatings form a film highly resistant to strong acids, alkalies, alcohols, salt solutions, moisture, oils and other paint-destroying corrosives.

Typical Performance Records

Ucilon Coatings used to line brine storage tanks in an alkali plant were in good condition after 5 years' remarkable service!

Concrete and steel storage tanks for gasoline and fuel oils are being lined with a Ucilon Coating System devised for these corrosives. It was found best of all linings tested—giving excellent resistance to cracking and no contamination by leaching.

A paper and pulp mill, using a Ucilon Coating System on wet ends of Fourdrinier machines, term it the *only material ever found to withstand the unusually severe, corrosive conditions.*

* * *

Send today for the CONDENSED UCILON BULLETIN that lists the 101 common corrosion problems and the Ucilon Coating Systems that offer you long lasting protection against each at lowest cost.

*Trade Mark

UNITED CHROMIUM, INCORPORATED

100 East 42nd St., New York 17, N. Y.

Waterbury 20, Conn. • Detroit 20, Mich. • Chicago 4, Ill. • Los Angeles 13, Calif.

In Canada: United Chromium Limited, Toronto, Ont.

NEW PRODUCTS —Materials—Service—Literature

M. J. Crose Manufacturing Co., Inc., Tulsa, has named Hartley Davis as manager of its Standard Magnesium Division, operation of which started October 6. The division was organized when Crose purchased the Standard Magnesium Company. The firm will make all standard shapes of anodes and will analyze spectroscopically each batch of anodes as a quality control measure. Sale and installation of anodes will be by Pipe Line Anode Corp., of which Yale Titterington is sales manager. Chief engineer for Pipe Line Anode will be Hugh Brady.

•

Naylor Pipe Co., 1230 East 92nd St., Chicago 19, Ill. has published a four-page illustrated bulletin on standard and specially fabricated fittings. Data includes specifications and prints on standard fittings for light-weight pipe. It also presents illustrations of special fabrications designed to save time and labor and reduce material costs in modernizing piping systems.

•

California Metal Enameling Co., Los Angeles, Cal. has developed a high temperature ceramic coating for protecting mild steel used in ladles, tanks and other equipment.

•

Hydrocide S-X 2210, is an aqueous solution of silicone resin compounds specifically designed for all masonry surfaces with a high lime content. It is invisible, non inflammable and will not discolor or wear away. Tests show an indicated life expectency of 10 years or more. More information may be had by writing L. Sonneborn Sons, Inc., 80 Eighth Ave., New York 11, N. Y.

•

Totrust Enamel Instant Dry is a free-flowing, high gloss tough enamel, highly resistant to chemical fumes. It dries in a matter of minutes, the makers say, with drying speed and qualities similar to lacquers. Among its uses are as a protective coating for exterior equipment, road equipment, and industrial machinery. A brochure showing the 24 colors available and full information as to the product's uses can be obtained by writing The Wilbur & Williams Co., Boston 35, Mass.

•

Metalweld, Inc., 26th and Hunting Park Ave., Philadelphia 29, Pa. has published a 12-page catalog outlining Metalweld's protective coatings, rubber lining, metal-spraying, welding and sandblasting services for industry. Electric welding, fabrication, oxy-acetylene welding for shaping, mechanical repairs, thermit welding for specialized work and lessening corrosion through hot sprayed metallic zinc and the use of hard or soft rubber linings, use of thermo plastic resins, sand blasting and other processes are discussed in the catalog.

•

Wallex No. 2 welding rods made by the Wall Colmonoy Corps., 19345 John R St., Detroit 3, Mich., give a deposit material consisting of chrome, manganese, silicon, iron alloy. This deposit has good abrasion and shock resistance and has stainless steel qualities approximately equivalent to Type 410 stainless steel, with a hardness ranging from 49 to 53 Rockwell C. It is available as electrodes in one-eighth, three-sixteenths and one-quarter inch sizes, 14 inches long. The firm has also published a 12-page catalog on "Colmonoy" hard facing alloys.

•

Crawford Fitting Co., Cleveland, Ohio, manufacturers of Swagelok Tube Fittings is marketing a new product, the Swagelok Heat Exchanger Tee. It is available in brass, aluminum, steel, stainless steel and monel and is precision made for numerous uses throughout laboratories and process industries. It was designed for steam jacketing or temperature control of process lines.

•

Isotope Products Ltd., Box 127, Oakville, Ont., Canada, have developed a means of testing, inspecting and measuring tanks by using isotopes. Tanks weighing 500 tons or more are being inspected for welding faults. The seams are individually radiographed with a continuous row of film. Isotope caesium 134, coupled with electronic level detection devices records the respective levels of oil and water in the tank. Location of lost "pigs" in pipe lines, the tracking and control of different kinds of petroleum products in a products line, and the logging of geologic formations is also being done by the use of isotopes.

•

Magnus 26N solution for providing temporary protection against rusting on steel parts has found a new use the makers, the Magnus Chemical Co., Garwood, N. J. say. Recently a maker of steel washers, found that Magnus 26N in a deburring barrel provided adequate assistance in deburring and at the same time was a good rust preventive. Now washers are thoroughly deburred while all traces of machining oil are removed. Magnus 26N leaves an almost invisible coating on steel parts which will last as long as the film remains. The film is soluble in water, however.

•

The Atlas Mineral Products Co., Houston, Tex. states it has developed a new type of construction for food plant floors which is resistant to all corrosives normally found in dairies, breweries, canneries, bottling plants, laundries and institutional kitchens. The construction consists of using Red Furane Cement for bonding the tile to the concrete slab and Black Furane Cement to fill the vertical joints between the tile. Trained crews install the flooring.

•

The Sparta Heat-Treat Co., East Sparta, Ohio has found a method of molding Teflon into intricate parts. Prior to the new method the company states it has been impossible to mold Teflon into parts requiring undercuts and other difficult forming details. Because of Teflon's excellent properties, it has been the practice to produce simple extrusions of the material and then machine the part into the more intricate shapes required. The Sparta Heat-Treat Co. claims the new method eliminates this costly procedure.

•

Water Service Laboratories, Inc., 423 West 126 St., New York 27, N. Y., have printed a two-page bulletin on the "Use of Water in Air Conditioning Systems." The causes of corrosion by water, the causes of scale formation by water, corrosion and scale preventive methods in open and closed systems and methods of cleaning the systems are given.

•

General Plastics Corp., P. O. Box 747, Marion, Ind., maker of "Genco" plastic pipe has published a six-page brochure describing its Genco and Tenite II pipe and fittings. Uses of the pipe, results of laboratory tests, correct methods of handling and other specifications are given.

•

Cathodic Protective Systems Ltd., 632 View St., Victoria, British Columbia has published an eight-page brochure explaining the firm's methods of corrosion and scale prevention. While the company specializes in protection of ships against corrosion by both fresh and sea water, it is prepared to plan and install all types of corrosion preventive systems.

•

The Uniflow Mfg. Co., Erie, Pa., maker of Uniflow Industrial Water Conditioning Equipment, as issued a mailing piece on the equipment and its uses. Photos show softening, filtration and iron removal installations. A capacity table is included. The firm will analyze water samples free and engineering advice also is offered.

•

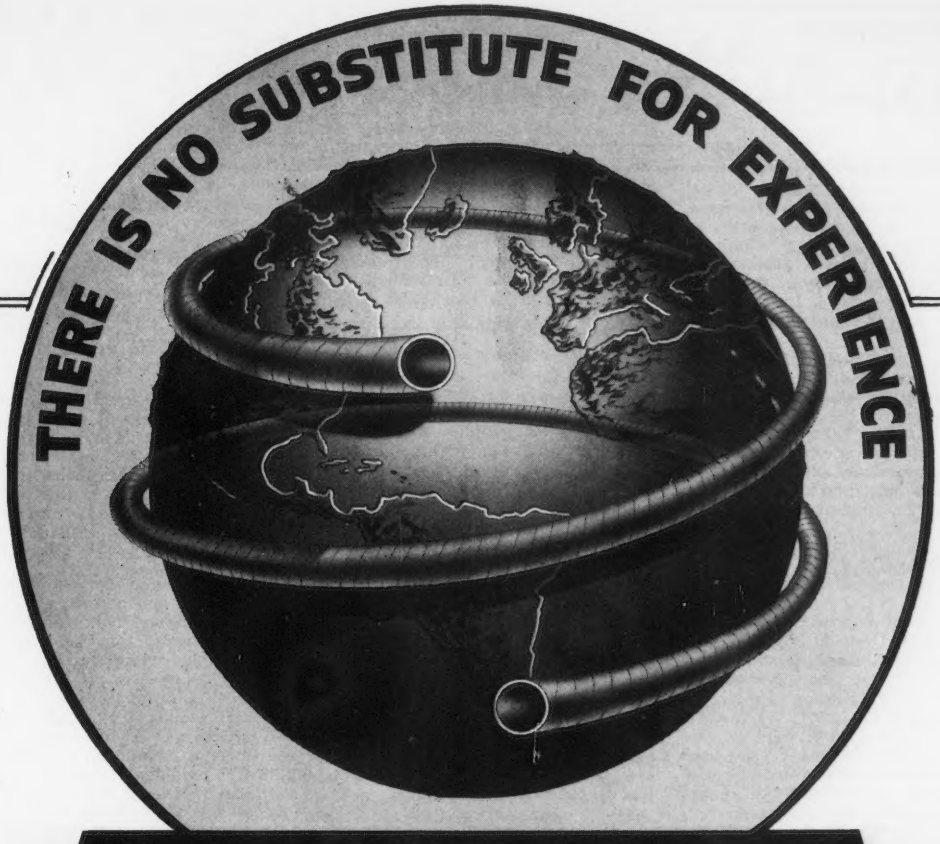
Tesco Chemicals, Inc., P. O. Box 173, Station C, Atlanta, Ga., has published a "manual of Metal Preparation Chemicals Used Prior to Application of Protective and Decorative Coatings." The manual includes chemical compounds, their use, equipment required, auxiliary operations and operational instructions for rust and corrosion proofing, paint bonding, brightening, cleaning, plating, vitreous enameling, pickling and paint stripping.

•

Alloy Rods Co., York Pa. has produced a 22-minute motion picture in full color and sound revealing the inside story on how arc welding electrodes are manufactured. The company states the film was edited and photographed to be an instructional and pictorial story intended mainly for showing before welding societies, engineering groups, metalworking industry organizations, college and university classes and others interested in arc welding techniques. Reputable organizations or groups may obtain the film by writing to the company, Department M. Title of the film is "No Finer Electrodes Made—Anywhere."

•

Curran Corp., Lawrence, Mass. is introducing a new pre-paint cleaner. The product, called "Gunk" solvent is used principally in the auto industry to remove the silicon polish film from the surface before spray painting.



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Are you being fair to yourself and your company when you buy pipe protection on price without questioning what you're getting for ***that*** price? Our price quotations give you unquestionable work backed by more than 25 years' experience, modern equipment and plant manned by skilled craftsmen, a 56-acre pipe yard on which more than 300 million feet of pipe (½" to 60") has been coated and wrapped to the entire satisfaction of the customers. This record is hard to match.

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PERSONALS

Herbert V. Evans, Jr. has been appointed district manager at Wilmington, Del. for the Alloy Steel Products Co., Inc. Mr. Evans formerly was sales representative for the company. In his new job, Mr. Evans will concentrate on direct selling activities in the Wilmington area, but will also have general supervision over the Pittsburgh territory which he formerly covered. He is a graduate of Boston College and served with the United States Army. **E. J. Lickwar** was appointed to fill the position vacated by Mr. Evans.

•

Patrick A. Cavuto, formerly in charge of the electroplating department of Muzak Corp., has joined the sales and service department of the Electroplating Division of United Chromium, Inc. He is now selling and servicing the complete line of Unichrome plating processes, materials and equipment in the New York City area.

•

J. W. Woodward has been appointed West Coast representative for the R. M. Hollingshead Corp., it was announced by Fred H. Lee, Jr., manager of the firm's Industrial Division. Mr. Woodward replaces **J. W. Reed, Jr.,** who was promoted to assistant manager of the Government Sales Division and reassigned to Camden, N. J. Mr. Woodward has specialized in hydraulic fluid system design, and his work on the West Coast will be with airframe manufacturers now equipping Naval aircraft with the company's new H-2 non-inflammable hydraulic fluid.

•

Alvin A. Meyrowitz, vice-president and general manager of the H. Kramer & Co., will direct the operation of the firm's new California Division plant at El Segundo. Mr. Meyrowitz, who was elected a vice-president of the firm on August 1, 1951 previously had been associated with the copper industry for about ten years through his work with various government departments. The California plant is said to be the most modern in the United States occupying 23 acres and including modern offices and laboratories. The plant includes two 60-ton reverberatory furnaces, two rotary type furnaces, a number of tilting furnaces, a cupola and radiator sweater. Included in the laboratory is a self-reading spectograph, which provides chemical analyses within 30 seconds. This provides rapid control to ensure that metal is being refined to exact specifications.

•

G. W. Huldrum, Jr., has been appointed sales manager, Eastern Division of Shell Chemical Corp., and **V. C. Irvine** has been named Western Division sales manager. In making the announcement, **J. Oostermeyer,** president, said that Mr. Huldrum replaces **J. G. Frye** who has resigned to take another post. Mr. Irvine will take the position formerly held by Huldrum. Mr. Huldrum will supervise all sales activities east of the Rocky Mountains for solvents, resins and plastics and industrial chemicals.

Appointment of **R. R. Huntington** as sales engineer in Louisiana, Mississippi and eastern Texas was announced by **A. J. Zino,** general Sales manager of the Joseph Dixon Crucible Co., Jersey City, N. J. Mr. Huntington, who has had more than 15 years' experience in the hardware jobber and industrial supply field, will sell Dixon crucibles, refractories silica-graphite paints, graphite and graphited lubricants.

•

Jack S. Brundage has joined the New England sales and service staff of the Organic Coatings Division of United Chromium, Inc. Mr. Brundage is a member of the New Haven Branch of the American Electroplaters' Society.

•

Dearborn Chemical Co., Chicago, Ill., manufacturers of water treatment chemicals, industrial cleaners and rust preventives, announces the addition of Mr. **Theodore B. Manheim** to its sales staff. He will take over the Philadelphia and Delaware territory and will make his headquarters in Philadelphia.

•

Kelite Products, Inc., manufacturers of cleaning and processing compounds and steam cleaning machines, has completed its new factory and sales offices at Berkeley Heights, N. J. Headquarters of Kelite are in Los Angeles, Calif., with additional plants in Chicago, Ill. and Dallas, Tex. The firm has service offices in 86 American cities and 15 foreign countries. **William Sorenson,** vice-president in charge of manufacturing, will head the new plant.

Corrosion Abstracts

CORROSION CONTROL — PROTECTS INDUSTRY — NATIONAL ASSOCIATION OF CORROSION ENGINEERS

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Vol. 8 November, 1952 No. 11

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1061 M & M Bldg. Houston, Texas

5. PREVENTIVE MEASURES

5.4 Non-Metallic Coatings and Paints

5.4.5, 5.4.8, 5.9.1

Manual on the Selection and Use of Paints. Div. of Building Research, National Research Council of Canada, Technical Report 6, 1950, 43 pages.

The following topics are covered; classes of paint, durability of paint, preparation of paints for use, preparation of surfaces for painting, methods of applying paint, and when to repaint. Includes glossary of paint terms and illustrations.—BLR.

5.4.5, 5.3.4

Polyvinyl Chloride for Corrosion Protection. R. NYLANDER AND V. BERGSTROM. *Teknick Tidskrift,* **80,** 1035 (1950); *J. Brit. Shipbuilding Res. Assoc.,* **6,** No. 2, 104 (1951).

A general description is given of the properties, uses and methods of application of polyvinyl chloride plastics in the form of film or spray coatings. A method of applying films by welding the edges of the individual sheets together by a high-frequency process is described, while, for spraying, the flame spray method akin to the metallizing processes is recommended. Brief reference is made to the use of this medium for the protection of laid-up aircraft and naval craft. —RPI.

5.4.8, 5.4.5

Hot Surface Paints for Marine Use. H. L. WARNEKE. *Marine News,* **37,** 35 (1950) Dec.; *J. Brit. Shipbuilding Res.*

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CODE OF AGENCIES SUPPLYING CORROSION ABSTRACTS

AER—Aeronautical Engineering Review, Institute of Aeronautical Sciences, Inc. 2 East 64th St., New York 21, N. Y.

ALL—The Abstract Bulletin, Aluminum Laboratories, Ltd. P. O. Box 84, Kingston, Onatrio, Canada.

AWWA—Journal, American Water Works Association. Amer. Water Works Assoc., 521 Fifth Ave., New York 17, N. Y.

BL—Current Technical Literature, Bell Telephone Laboratories, Inc., Murray Hill, N. J.

BLR—Battelle Library Review, Battelle Memorial Institute Library. 505 King Ave., Columbus, Ohio.

BNF—Bulletin; British Non-Ferrous Metals Research Association. 81-91 Euston St., London NW 1, England.

CALCO—Calco Chemical Division, American Cyanamid Corp. Bound Brook, New Jersey.

CE—Chemical Engineering, McGraw Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

CEC—Consolidated Edison Co. of New York, Inc. 4 Irving Place, New York 3, New York.

EL—Electroplating. 83/85 Udney Park Road, Teddington, Middlesex, England.

EW—Electrical World, McGraw-Hill Publishing Co. 330 W. 42nd St., New York 18, N. Y.

GPC—General Petroleum Corp. of California. 2525 East 37th St., Los Angeles 11, Calif.

INCO—The International Nickel Co., Inc. 67 Wall Street, New York 5, New York.

IP—Institute of Petroleum. 26 Portland Place, London W#1, England.

MA—Metallurgical Abstracts, Institute of Metals, London, England. 4 Grosvenor Gardens, London SW 1, England.

MI—Metallurgia Italiana. Associazone Italiana di Metallurgia. Via S. Paola, 10, Milano, Italia.

MR—Metals Review, American Society of Metals. 7301 Euclid Ave., Cleveland 3, Ohio.

NALCO—National Aluminate Corp. 6216 West 66th Place, Chicago 38, Illinois.

NBS—National Bureau of Standards. Supt. of Documents, U. S. Gov't Printing Office, Washington 25, D. C.

NSA—Nuclear Science Abstracts. United States Atomic Energy Commission, Technical Information Division, Oak Ridge, Tenn.

PDA—Prevention Deterioration Abstracts. National Research Council, 2101 Constitution Ave., Washington 25, D. C.

RA—Refrigeration Abstracts, American Society of Refrigeration Engineers. 40 West 40th St., New York 18, N. Y.

RM—Revue de Metallurgie, Paris, France. 5 Cite Pigalle, Paris (9e), France.

RPI—Review of Current Literature Relating to the Paint, Colour, Varnish and Allied Industries, Research Association of British Paint, Colour & Varnish Manufacturers, London. Waldegrave Rd., Teddington, Middlesex.

TDD—Technical Data Digest, Air Material Command—Technical Service Section, Central Air Documents Office, Wright-Patterson Air Force Base, Dayton, Ohio.

TIME—Transactions of Institute of Marine Engineers. 85 The Minories, London EC 3, England.

UOP—Universal Oil Products. 310 South Michigan Ave., Chicago, Illinois.

ZDA—Zinc Development Association. Lincoln House, Turl Street, Oxford, England.

Assoc., **6**, Abstract No. 4, 631 (1951) Mar.

Boiler fronts, furnace doors, etc., which are exposed to red or orange heat at times, present a difficult painting problem. The usual method of covering these hot parts is to apply a thin coating of special varnish which contains aluminum flake or zinc dust. Then, at the elevated temperature in question, the vehicle is burnt out, and the metallic flake sintered on to the metal surface. This is only feasible if the metal to be protected is clean and free from any interfering material. For the best results, a very thin aluminum paint is recommended, with a high aluminum-flake content of 2 to 2½ lb. per gallon. This paint should be a fast-drying type to avoid retaining solvent and thinner in a partially dried film, which may blister when heat is applied. A new grey metallic paint, to which a special cement has been added, has shown outstanding results, even on surfaces exposed to the weather. As the oil burns out and the metallic pigment shows definite sintering action, the cement, in taking up moisture gradually, provides a very resistant outside coating.—TIME.

5.8 Inhibitors and Passivators

5.8.2, 4.6.2, 7.2

Plant Stops Return Line Corrosion—Saves $14,200 a Year. ERLE ELLIOTT AND P. J. GAUGHAN. *Power Plant Eng.*, **55**, No. 8, 104, 106-107, 109 (1951) Aug.

Boiler return line grooving and pitting corrosion is due to both dissolved carbon dioxide and oxygen in the return condensate. The corrosion was curtailed by the application of a film-forming octadecylamine, Permacol, to the low-carbon steel pipe.—INCO.

5.8.2, 5.8.4

Corrosion Inhibitors. *Electroplating*, **4**, No. 5, 165-166 (1951) May.

Janex Rust Preventative is used where the metal surface of the article is to be protected against corrosion during storage and is a coating which can readily be washed off when required by means of paraffin. Rustex, a corrosion inhibitor, is of use for application to metal surfaces prior to painting and, it is claimed, effectively prevents corrosion of the metal underneath the paint film. Tractol paints are suitable for application to surfaces which have been treated with Rustex corrosion inhibitor. Tractol undercoating contains zinc chromate as a rust inhibiting pigment and drys very rapidly to give a flexible film with excellent adhesion to metal. All manufactured by William Sim & Sons of Leith, Edinburgh, 6.—INCO.

5.8.2, 5.6.2, 1.2.4

Vapor Packaging Keeps Rust Off Weapons, Tools. MAJ. G. FOSTER, USAF. *Iron Age*, **7**, No. 23, 167, 99-103 (1951) June.

The military services are making use of a promising new family of rust preventives called volatile corrosion inhibitors. This unique method of using vapors to prevent rust is playing an increasingly important part in the packaging of weapons. The applications discussed in this article are military but the methods set forth can be easily adapted for industrial use. A new government specification covers the new rust preventives that inhibit corrosion by surrounding ferrous weapons and machine tools with protective vapor. Readying a grease-coated M-1 rifle for combat required at least three hours of hard work. A weapon in a corrosion inhibitor wrapper can be fired minutes after it is unwrapped and wiped off. Cleaning damage is eliminated.—CADO.

5.8.2, 8.4.3

Some Applications of Organic Corrosion Inhibitors in the Petroleum Industry. C. M. BLAIR. Tretolite Co. Paper before NACE, 7th Ann. Conf. & Exhib., New York, Mar. 13-16, 1951. *Corrosion*, **7**, No. 6, 189-195 (1951) June; discussion, *ibid.*, No. 9, 316, Dec.

History of the application of organic inhibitors for the abatement of corrosion in the petroleum industry is reviewed. Mechanics of inhibitor use and recommended methods of application are discussed. Corrosion rate data are presented for a number of typical systems in which organic corrosion inhibitors are used. These systems include oil wells, gas condensate wells, gas lines, water injection systems, gasoline plant stripping columns and refinery processing units. The question of the mechanism of the action of organic inhibitors in reducing corrosion rates of metals is briefly considered. Laboratory and field data on the relation between inhibitor concentration and corrosion rate are analyzed and compared with the predictions of corrosion rate derived from adsorption theory. Diagrams, graphs and tables are included. 15 references.—INCO.

5.8.2, 5.9.2, 6.2.3

A Contributor Discusses Inhibitor Practice. *Wire Industry*, **17**, 165 (1950) Feb.

Action of chemical corrosion inhibitors as applied to pickling of steel, especially in the form of wire.—MR.

5.8.2, 4.6.3

Use of Corrosion Inhibitors in De-Icing Salt. MARVIN L. DAVIS. Am. Public Works Association. *Proc. Public Works Congr.*, **55**, 236-247 (1949) Aug.

Only 4 percent of a group of 1947 model cars showed slight corrosion after driving during one winter on Akron, Ohio, streets that had been de-iced with refuse salt containing 1 percent sodium dichromate as an anticorrosive additive; the remaining 96 percent were corrosion free. Of a number of 1946 model cars driven during one winter in streets de-iced with refuse salt only, and a second winter in streets de-iced with the 1 percent dichromate—refuse salt mixture, 4 percent showed medium corrosion, 68 percent slight corrosion, and 28 percent no corrosion. Greater and probably optimum corrosion inhibition can be expected from a 2 percent dichromate—refuse salt mixture. Cars specially treated against corrosion and those having low mileage were excluded from these tests. Of a total of 116 cars tested, more than 50 percent were in the lower price range.

Examination of steel panels attached to test cars in Michigan and New York showed that corrosion caused by de-icing salt is reduced by 23 percent if approximately 0.4 percent "Banox," a readily available, nontoxic, vitreous metaphosphate inhibitor, is added. A 1 percent concentration can be expected to reduce corrosion rates by 50 percent and to give optimum results. Tests with steel panels showed that Banox, as well as "Nalco 818-C," a commercial nitrite-polyphosphate inhibitor containing a strontium salt, are as effective as sodium dichromate. Alkali phosphates greatly increase the penetrating power of de-icing salt solutions, thus enabling them to creep into joints and crevices of automobile bodies and to give corrosion protection to relatively inaccessible places and even to metal covered with rust.

PDC Comment: Laboratory tests have shown that a 1 percent concentration of Nalco 818-C effectively prevents corrosion of mild steel panels by brines containing more than 9 percent sodium chloride by weight, and that a 0.5 percent inhibitor concentration decreases by as much as 90 percent the corrosion caused by 25 percent brines. In the city of Rochester, which used this inhibitor during the 1948-50 winter seasons, not a single complaint by local automobile owners or clubs was registered as compared with thousands of complaints received in the winter of 1947-48 when no inhibitor was added to the de-icing salt used. Control of Corrosion by Salt Used for De-Icing Highways, *Corrosion*, **6**, 391-394 (1950). —PDA.

5.8.2, 5.8.4

Redox Couples for Protection of Metals Against Attack by Water-in-Oil Emulsions. J. RZYMKOWSKI AND REITSTÖTTER. *Angew. Chem.*, **62**, 49 (1950).

Inorganic passivators (e.g., chromates) may flocculate fine emulations, but diphenyl amine does not do so, and has been used with success. Quinones are ineffective.—RPI.

5.8.3, 7.4.2

Corrosion and Film Protection. ANTHONY JOHN PHILLIP TUCKER. Abs. Dissert. Univ. Cambridge, 1948-49, **1950**, 126-127.

Experiments designed to simulate conditions in aircraft-cooling systems and the corrosion that occurs when inhibitors, including triethanolamine and sodium phosphates, both alone and with sodium mercaptobenzothiazole, and oil emulsions alone or with sodium phosphate or nitrate, are added to 30 : 70 ethylene glycol/water mixture are described. The reaction between copper and solutions of sulfur is influenced by previous surface treatment of the metal and the disposition of the copper specimens in, and the concentration of, the solutions. The formation and nature of interference films formed on electropolished brass, copper and silver by the deposition of sulfur are studied. —MA.

5.8.3, 6.2.2

The Mechanism of the Inhibition of the Corrosion of Iron by Solution of Sodium Orthophosphate. M. J. PRYOR AND M. COHEN. Paper, Electrochem. Soc. Meeting, Buffalo, N. Y., Oct. 11-13, 1950. *J. Electrochem. Soc.*, **98**, 263-272 (1951) July.

A study was made of the behavior of iron exposed to solutions of sodium phosphate both in the presence and absence of air. It was found that decimolar solutions of sodium orthophosphate passivate freshly abraded iron at pH values above 7.25 in the presence of air. When the solutions are deaerated the iron corrodes and exhibits negative potentials of the order of —0.50 to —0.65 volt. The rate of corrosion decreases and the potential becomes more negative as the pH of the solution increases. The shape of the potential-time curves and polarization curves indicates that this corrosion is largely under cathodic control. It is suggested that oxygen dissolved in solu-

tion is mainly responsible for the ability of phosphate solutions to inhibit iron corrosion.

5.8.3

Cathodic Corrosion—Cause and Prevention. *S. A. E. Journal,* **58,** 96, 98 (1950) Aug.

Based on "Cathodic Control of Corrosion by Hiram Walker. Mechanism of cathodic protection and how it is used for preservation of underground structures, ship hulls, steel piling, docks, heat exchangers, condensers and pipe lines carrying sea water.—MR.

5.9 Surface Treatment

5.9.1, 5.3.1, 1.6

Metal Finishing Handbook. P. A. CARTWRIGHT. (Book) 216 pages. 1950. Blackie and Son, Ltd., 66 Chandos Place, London, W.C. 2, England.

Processes used in providing permanent metal-protective finishes. Pre-treatment of metal surfaces by grinding, polishing, burnishing, chemical cleaning, pickling, scratch-brushing, and stripping. Electroplating; and the electrodeposition of metals such as nickel, copper, chromium, cadmium, zinc, lead, etc., also decorative plating processes. Metal coloring by bronzing, oxidizing, blueing, lacquering, coloring of silver, gold, tin, nickel, aluminum, etc. Brief description of phosphate and allied coatings. Testing of coatings for adhesion, thickness, porosity and corrosion resistance.—MR.

5.9.2, 5.9.3, 1.4

Metal Cleaning Bibliographical Abstracts. J. C. HARRIS. ASTM Special Tech. Pubn. No. 90, 1949, 68 pp. Published by the Society, 1916 Race Street, Philadelphia 3, Pa. $2.75.

This publication supersedes the earlier bibliography of Harris and Mears (mainly on aluminum cleaning) published in *ASTM Bulletin,* May 1944, No. 128, pp. 35-40. It gives 494 references on cleaning, pickling, corrosion inhibitors, etc., together with short abstracts. Several of the abstracts are taken from *Chem. Abs.* or from *Met. Abs.* (which is incorrectly referred to as *J. Inst. Metals*). The references are classified firstly by year, secondly by author; they are indexed by subject, author, standard specifications and patents.—BNF.

5.9.2

The Degreasing of Metals at Room Temperatures. *Machinery Lloyd,* **22,** No. 17, 99 (1950).

Reference is made to a room-temperature cleaning solution with a flash point of 100° F (38° C), which does not contain any petroleum spirit. This process is sufficient for preparing metal surfaces for painting, enamelling, phosphating and anodizing. An after-treatment with an alkaline cleaner is necessary for electroplating.—MA.

5.9.2

Development of Alkaline Cleaners. R. H. TIERS. *Metal Finishing,* **48,** No. 4, 49-53 (1950).

A review of alkaline cleaning materials and methods is given, methods for determining the cleanness of metals being also mentioned.—EL.

5.9.2, 5.9.3

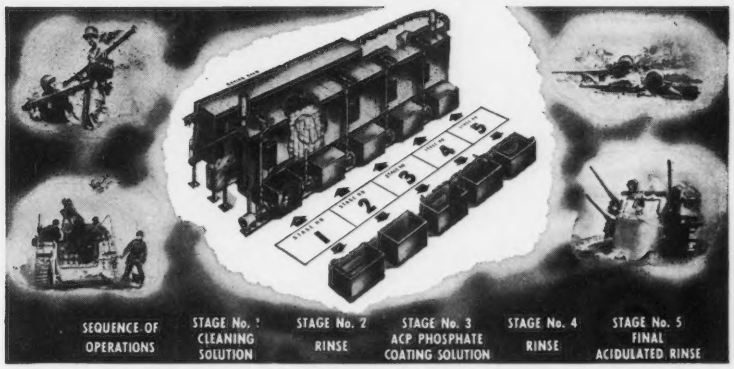
When To Use Electrolytic Polishing.

AMERICAN CHEMICAL PAINT COMPANY

AMBLER CHEMICALS ACP PROCESSES PENNA.

Technical Service Data Sheet

Subject: METAL PRESERVATION AND PAINT PROTECTION WITH ACP PHOSPHATE COATING CHEMICALS


SEQUENCE OF OPERATIONS
STAGE No. 1 CLEANING SOLUTION
STAGE No. 2 RINSE
STAGE No. 3 ACP PHOSPHATE COATING SOLUTION
STAGE No. 4 RINSE
STAGE No. 5 FINAL ACIDULATED RINSE

U.S. ARMY PHOTOGRAPHS COURTESY OF "ORDNANCE MAGAZINE"

Typical spray and dip phosphating equipment and some ordnance products that are now given a protective phosphate coating for extra durability under all kinds of severe exposure conditions. Both military and civilian applications of ACP phosphate coating chemicals are shown in the chart below.

SELECTION CHART OF ACP PROTECTIVE COATING CHEMICALS FOR STEEL, ZINC, AND ALUMINUM

METAL	ACP CHEMICAL	OBJECT OF COATING	TYPICAL METAL PRODUCTS TREATED	GOVERNMENT SPECIFICATIONS
STEEL	"GRANODINE" Zinc Phosphate Coating Chemical	Improved paint adhesion	Steel, iron, or zinc fabricated units or components, automobile bodies, refrigerators, washing machines, cabinets, etc.; projectiles, rockets, bombs, rifles, small arms, belt links, cartridge tanks, vehicular sheet metal, tank bolts and links, recoilless guns, etc.	MIL-S-5002 JAN-C-490, Grade I JAN-F-495 U.S.A. 57-0-2, Type II, Class C U.S.A. 51-70-1, Finish 22.02, Class C U.S.A. 50-60-1 16 E4 (Ships)
	"PERMADINE" Zinc Phosphate Coating Chemical	Rust and corrosion prevention	Nuts, bolts, screws, hardware items, tools, guns, cartridge clips, fire control instruments, metallic belt links, steel aircraft parts, certain steel projectiles and many other components.	MIL-C-16232 U.S.A. 57-0-2, Type II, Class B U.S.A. 51-70-1, Finish 22.02, Class B Navy Aeronautical M-364 U.S.A. 72-53 (See An-F-20)
	"THERMOIL-GRANODINE" Manganese-iron Phosphate Coating	Wear-resistance anti-galling, safe break-in of friction or rubbing parts. Rust proofing.	Friction surfaces such as pistons, piston rings, gears, cylinder liners, camshafts, tappets, crankshafts, rocker arms, etc. Small arms, weapon components. Hardware items, etc.	MIL-C-16232 U.S.A. 57-0-2, Type II, Class A U.S.A. 51-70-1, Finish 22.02 Class A Navy Aeronautical M-364 U.S.A. 72-53 (See AN-F-20)
	"GRANODRAW" Zinc-iron Phosphate Coating	Improved drawing, extrusion, and cold forming	Blanks and shells for cold forming, heavy stampings; tubs; tubing for forming or drawing; wire; rod; etc.	———
ALUMINUM	"ALODINE" Protective Coating	Improved paint adhesion and corrosion resistance	Aluminum products of similar design such as refrigerator parts, wall tile, signs, washing machine tubs, etc; aircraft and aircraft parts; bazookas (rocket launchers), helmets, belt buckles, clothes dryers, clothesline, rocket motors, etc., aluminum strip or sheet stock.	MIL-C-5541 (See also QPL-5541-1) MIL-S-5002 AN-F-20 U.S. Navord O.S. 675 16 E4 (Ships) AN-C-170 (See MIL-C-5541) U.S.A. 72-53 (See AN-F-20)
ZINC	"LITHOFORM" Zinc Phosphate Coating Chemical	Improved paint adhesion	Zinc alloy die castings; zinc or cadmium plated sheet or components; hot dip galvanized stock; galvanneal; signs; siding; roofing; galvanized truck bodies; etc.	QQ-P-416 RR-C-82 JAN-F-495 AN-F-20 U.S.N. Appendix 6 U.S.A. 72-53 (See AN-F-20)

CHEMICALS ACP PROCESSES

WRITE FOR DESCRIPTIVE FOLDERS ON THE ABOVE CHEMICALS AND FOR INFORMATION ON YOUR OWN METAL PROTECTION PROBLEMS

CHEMICALS ACP PROCESSES

C. E. NAYLOR. *Plating Notes,* **2,** 91-95 (1950) June.

Limitations of electropolishing as a production process, and recommendations concerning its application to the finishing of specific alloys and articles. Status of the process, particularly its use in conjunction with mechanical polishing.—MR.

5.9.3

Flame De-Scaling of Metal Surfaces. *Trav. Peinture,* **5,** No. 5, 285-286 (1950).

A description of flame de-scaling using an oxy-acetylene blowpipe. The advantages over pneumatic hammers, rotary steel brushes, etc., are described.—RPI.

5.9.4

Rust Proofing Improved by Polymerized Phosphate Coat. DON VANCE. *Western Metals,* **8,** 25-26 (1950) Nov.

Advantages of "Polykote" process developed by Kelite Products, Los Angeles. A catalyst is used to produce polymerization of the phosphate crystals, resulting in continuous rather than discontinuous protection.—MR.

5.9.4, 3.5.9

The Oxidation of Heat-Resistant Alloys in the Presence of Foreign Oxides. J. L. MEIJERING AND G. W. RATHENAU. *Philips Tech. Rev.* (Holland), **12,** No. 8, 213-220 (1951) Feb.; *Engrs. Digest,* **12,** No. 4, 129 (1951) Apr.

Alloys which are protected against corrosion by a dense oxide film, and thus may serve as heat-resistant constructional materials, sometimes show a strongly accelerated oxidation when brought in contact with foreign oxides. The oxidation of a series of metals and alloys including those with copper, iron and silver as base, has been investigated where these are brought in contact with molybdenum oxide (molybdenum oxide in powder form). It can be concluded that the accelerated oxidation, appearing to lie at the eutectic temperatures of the systems of the respective oxides, is due to formation of liquid in the protective oxide film of the alloy.—INCO.

5.9.4

Die Entwicklung Und Anwendung Der Atramentverfahren Unter Den Heutigen Wirtschaftsbedingungen. (Development and Application of the Atrament Process Under Present Economic Conditions.) F. ROSSTEUTSCHER. *Arch. Metallkunde,* **3,** No. 2, 66-71 (1949) Feb.

A survey is made of the development and applicability of the five major types of Atrament phosphatizing processes (Atrament A, Zi, C, K, and M). The last three are potentially economical treatments for metals.

The phosphatizing bath for Atrament A is prepared by dissolving 3.5 kg or 2.5 liters Atramentol A and a trace of iron in 100 liters tap water. Atramentol A contains a 6:1 mixture of manganese dihydrogen phosphate and free phosphoric acid of 1.4 specific gravity. In freshly prepared baths, gray-to-black coatings are produced within 40-60 min. but in used baths treating time is extended to 2 hours or longer because the bath exhibits progressive sludge formation on use. The treating time can be shortened by the addition of nitrogen-containing organic compounds such as aniline. The coatings are porous and absorb appreciable quantities of oil or other sealing materials. Good mechanical and chemical pretreatment, cleaning of the metal surface, and thorough rinsing of the phosphatized surface are essential.

Modifying this treatment by using a double amount of Atramentol A plus 1 g bisulfite per liter produces, after 15-20 minutes immersion at 50°-55° C, regular, finely crystalline, black coatings having fair corrosion resistance; however, the development of sulfurous acid and appreciable sludge are major disadvantages.

The treating solution for Atrament Zi consists of 4.8 kg or 3 liters Atramentol Zi in 100 liters water at 96°-98° C. Atramentol Zi consists of a 1.5:1 mixture of zinc dihydrogen phosphate and phosphoric acid. Immersion time depends mainly on the nature of the metal surface. The disadvantages of this bath include short life of the coatings, appreciable sludge formation, and attack on the walls of the containers.

The Atrament C process uses the same ingredients in the same proportion as the Atrament Zi process, except that 0.51 kg zinc chlorate is added. The treating time is 2-10 min at 92°-95° C, and a much denser, interwoven texture of needle-like crystals is produced. The coatings are only 1.5-5 μ thick but possess superior durability, flexibility, and insulating capacity.

They are resistant to temperatures up to 225° C and form an excellent substrate for economical amounts of paints and lacquers. Proper adjustment of the chlorate content reduces corrosion of substrate by the zinc chloride that is formed on destruction of the zinc chlorate. This process has wide application and the two ingredients Atramentol C and chlorate accelerator can be stored indefinitely even at temperatures as low at —50° C. A rapid treatment that can be applied cold is Atrament K, in which 3.5-5.25 liters zinc dihydrogen phosphate containing a smaller portion of free phosphoric acid than does Atramentol C are dissolved per 100 liters water, and 4 liters of chlorate accelerator are added. The resulting coatings are 1-3 μ thick and more flexible than those produced by the Atrament C method. Atrament K is also more economical and produces such a finely dispersed sludge that it hardly interferes with the coating formation.

A 1:1 mixture by volume of Atramentols A and C forms the basis for the Atrament M process, which has special merit for zinc and zinc alloys. The treating bath consists of 4.5 kg or 3 liters Atramentol M per 100 liters water. A treating time of 2-5 min at 95° C produces excellent uniform phosphate coatings.

5.9.4, 6.3.19, 5.9.2

Conversion Coatings on Zinc. F. TAYLOR. *Products Finishing,* **14,** No. 11, 38-39 (1950).

Some comments on the article by V. Mattacotti (*Review,* 1950, 627_2). Quick and accurate methods are available for estimating the dichromate radical, sulfuric acid and the chromium ion (Cr^{3+}) in passivation solutions, rendering unnecessary the indirect method given by Mattacotti. The composition of solutions suited to particular kinds of work is discussed, and additional possible reasons for unsatisfactory results are given.—RPI.

5.9.4, 2.4.3, 2.3.9

Methods of Evaluating the Efficiency of Anodic Oxide Films. (In Italian.) G. MISSIER AND W. RUFF. *Alluminio,* **19,** No. 6, 515-522 (1950).

Review of three non-destructive and four destructive methods showed that the most accurate were the determination of the weight or volume of the coating; other methods discussed are measurement of the perforation voltage, microscopic thickness measurement, direct measurement after detaching with mercury chloride and direct measurement with a precision micrometer.—BNF.

5.9.5, 6.4.2

Electrical Capacity of Porous Aluminum Oxide Layers. A. J. DEKKER AND H. M. A. URQUHART. *Can. J. Research,* **28,** No. 9, 541-50 (1950).

Porous aluminum oxide layers may be obtained by anodic oxidation in sulfuric acid. The base of the pores is separated from the metal by a thin insulating barrier layer. The experiments show that the ultimate thickness of the barrier remains constant after a critical value has been reached. The dependence of the final thickness on current density, concentration and temperature has been investigated. It is suggested that an electronic current is involved in the mechanism which limits the growth of the barrier layer.—RPI.

6. MATERIALS OF CONSTRUCTION

6.2 Ferrous Metals and Alloys

6.2.2, 6.2.5

Corrosion—Cast Irons—Inexpensive Engineering Materials. M. G. FONTANA. *Ind. and Eng. Chem.,* **43,** No. 3, 71A-72A+ (1951) Mar.

Cast irons are inexpensive engineering materials and are used for many corrosion applications. In some cases it is necessary to protect the metal with coatings and/or cathodic protection. Cast iron will resist a wide variety of acids including strong sulfuric acid, concentrated nitric acid, mixed sulfuric acid and nitric acid with water contents up to 20 percent, some commercial concentrated phosphoric acids and chromic acid. Durion (14.5 silicon cast iron) is perhaps the most universally resistant alloy commercially available with respect to acids (except hydrochloric acid). Nickel improves the resistance of ordinary cast iron to acids, alkalies and other media. An example is Ni-Resist, a high nickel austenitic iron. Ni-Hard, a white cast iron, gives excellent service in alkaline slurries where erosion-corrosion is involved.—INCO.

6.2.5, 6.3.10, 2.3.2

The scaling Process and Short-Time Tests of the Life of Heat-Conducting Alloys. (In German). HELMUT KRAINER, LEOPOLD WETTERNIK, AND CARL CARIUS. *Arch. Eisenhuttenw,* **22,** 103-110; disc., 110 (1951) Mar.-Apr.

Describes test results for a steel containing 25 percent chromium and 20 percent nickel, an alloy of 80 percent nickel and 20 percent chromium; and a steel containing 24 percent chromium and 5.5 percent aluminum. Resistance of these alloys to temperature changes differs widely. Short-time tests indicate that no simple correlation exists between scaling and life. The problems of wire thickness, test temperature and time, and reproducibility of results are discussed. Data are tabulated and charted. 23 references.—BLR.

6.2.2

Cast Iron From the Point of View of the Purchaser. W. P. SMITH. *Foundry Trade J.*, **88,** 139-146 (1950) Feb. 9.

Procedures for testing purchased castings, both by nondestructive and destructive methods. Examples are quoted and related to foundry processes.—MR.

6.2.5, 3.5.9

Behavior of Steel at Elevated Temperatures. Survey of Literature for the Years 1948 and 1949. (In German.) ANTON POMP. *Stahl u. Eisen*, **70,** 791-794 (1950) Aug. 31; 848-853 (1950) Sept. 14.

Mechanical-test apparatus. Second part charts and tabulates elevated-temperature properties of various stainless and high-alloy steels. 65 references.—MR.

6.2.5, 8.1.2, 7.4.2

Stainless Jackets for Cold Water Exterior Risers. *Sheet Metal Worker*, **42,** 44, 46 (1950) Nov.

A practical way of providing air conditioning for an older type building was solved by running chilled water risers up the south side. They are protected by stainless-steel columns that add a modern note to the building.—MR.

6.2.5, 5.10

Chipboard Eliminates Corrosive Etching on Steel Sheets. *Iron Age*, **165,** 85 (1950) Feb. 23.

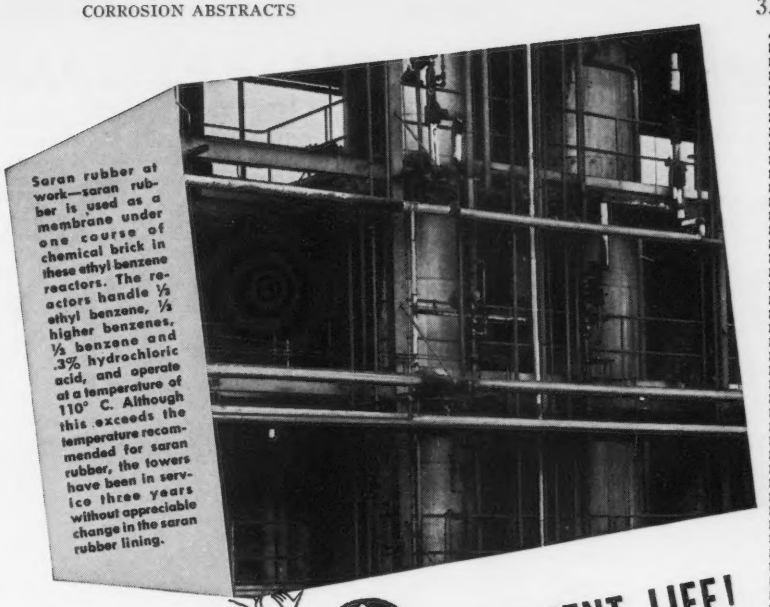
How etching normally occurring on the bottom sheet of stacks resting on wooden skids and pallets can be eliminated by use of a specially coated chipboard made from pulpboard used in making paper boxes.—MR.

6.3 Non-Ferrous Metals and Alloys—Heavy

6.3.20

Ten Zirconium Alloys Evaluated. F. B. LITTON. *The Iron Age* (U.S.A.), **167,** No. 14, 95-99 (1951) Apr.

Commercially pure titanium will eventually find wide application in everyday commercial use because of its excellent corrosion resistance. The Foote Mineral Co. has conducted research under the sponsorship of the Engineering Division. Air Materiel Command, on possible alloys of zirconium which are less corrosion resistant but offer improved mechanical properties. During the exhaustive research into the possible alloys which could be effectively used, many elements were discarded. The metals having inter-atomic distances within 20 percent of zirconium were divided into two classes, depending on their boiling temperature relative to the melting point of zirconium, 1750° C. (3182° F.). Also included in the low boiling group were metals possessing distinct electro-positive and electro-negative chemical behavior. These metals were magnesium, indium, lithium, cadmium, thalium, antimony, cerium and zinc which were eliminated. Solubility was predicted on addition of hafnium, tin, titanium, silver, aluminum, tantalum, columbium and lead. It was found that tin and aluminum formed intermetallic compounds, while titanium was completely miscible in zirconium. Lead was also eliminated due to differences in density and melting point relative to zirconium. Borderline metals were tungsten, thorium, manganese, vanadium and


Saran rubber at work—saran rubber is used as a membrane under one course of chemical brick in these ethyl benzene reactors. The reactors handle ⅓ ethyl benzene, ⅓ higher benzenes, ⅓ benzene and .3% hydrochloric acid, and operate at a temperature of 110° C. Although this exceeds the temperature recommended for saran rubber, the towers have been in service three years without appreciable change in the saran rubber lining.

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copper. The following elements were chosen for investigation of tensile and oxidation data: hafnium, titanium, aluminum, tantalum, columbium, tungsten, molybdenum, copper, oxygen and nitrogen.

Zirconium alloys were prepared for the investigation by the following methods: 1) vacuum melting in graphite crucible using either high-frequency current or a carbon resistor sleeve for heating; 2) are melting in a water-cooled copper crucible under purified inert atmosphere; 3) codepositing the alloy in an improved deBoer deposition cell; 4) diffusion of element into zirconium. Melting in graphite crucibles appears to have more immediate commercial promise. The tensile properties determined during the investigation are tabulated for the following alloys: zirconium-hafnium alloys, zirconium-titanium alloys, zirconium-aluminum alloys, zirconium-tantalum alloys, zirconium-columbium alloys, zirconium-tungsten alloys, zirconium-copper alloys, zirconium-molybdenum alloys. The effect of oxygen and nitrogen combined on the tensile and yield strength of samples, and the tensile strength, hardness relationships on the oxygen plus nitrogen alloy, are shown in graphical form.—ALL.

6.3.3, 3.7.4

Chromium-Base Alloys. W. L. Hevekotte, C. T. Greenridge, and H. C. Cross. *Proc. Am. Soc. Testing Materials,* **50,** 1101-1130 (1950).

A condensed version of the final report which summarized results of research conducted at Battelle from Oct. 1945 to Mar. 1950, on above alloys, particularly the 60Cr-15Fe-25Mo type, for Office of Naval Research. Main topics are the melting and casting apparatus consisting of a beryllia-crucible, molybdenum-sheet induction furnace; preparation of test materials; microstructures; mechanical properties; and high-temperature oxidation resistance. Also discusses mechanism of microcrack formation and role of plastic deformation.

6.3.5, 3.7.3

Heat Treatment and Structure of Commercial Titanium. J. Maltz and V. DePierre, U. S. Naval Gun Factory. *Metal Progress,* **58,** No. 6, 862-866 (1950) Dec.

The solubility of carbon in either alpha or beta titanium is very much less than 0.78 percent over a wide range of temperature. The addition of carbon to titanium and the pick-up of atmosphere oxygen and nitrogen widen the temperature range of the alpha-beta transformation. Beta titanium is not retained in appreciable quantity when commercial titanium is quenched, nor is a hard transition phase formed. The material is consequently not hardened by quenching. The microstructure of quenched titanium bears some resemblance to that of martensite. The hardness of quenched titanium is not greatly affected by tempering. No change in structure occurs except for a gradual fading of the martensitic pattern and emergence of a pattern of resolvable alpha titanium grains.—TDD.

6.3.6, 3.7.4

Copper and Copper Alloys; Technical Progress in 1949. E. Voce. *Metallurgia,* **41,** 150-152 (1950) Jan.

Joining, corrosion, recrystallization, grain growth and applications. 107 references.—MR.

6.3.6

Stabilization of Copper Powder in Regard to Corrosion. (In Russian.) A. I. Levin and A. V. Pomosov. *J. Applied Chem.* (USSR) (Zhurnal Prikladnoi Khimii), **23,** No. 9, 949-957 (1950) Sept.

Study of the effectiveness of various organic compounds in protecting copper powder from corrosion during manufacture and storage. Sodium soap was found to be best.—BNF.

6.3.6, 3.4.6, 7.4.2

The Corrosion of Brass Tubes by River Water and Its Prevention. J. Bunger. *Werkstoffe u. Korrosion,* **1,** No. 4, 133-136 (1950); *J. Inst. Metals,* **18,** Pt. 8, 530 (1951) Apr.

The corrosion of condenser and coolant tubes, made from brasses of various compositions and structures, by condensate, containing ammonia and oxygen and by soft river water of high chloride content is described. Dezincification and stress-corrosion can be minimized by the use of a high-purity, straight 70:30 brass, or one containing 1% tin, and having a fine, uniform, recrystallized structure and a proof stress of 17-21 kg/sq.mm.—INCO.

6.3.6, 4.6.11

Copper-Nickel-Iron Alloys Resistant to Sea-Water Corrosion. G. L. Bailey. *British Non-Ferrous Metals Research Supplement,* Confidential Report, **2,** Oct. 1950. *J. Inst. Metals,* **79,** Pt. 5, 243-292 (1951) July.

The development of copper alloys containing 5-10 nickel and 1-2 iron as materials easily worked by the coppersmith and resistant to corrosion by moving sea water are described. An account is given of some early work on the effect of small additions of iron and manganese on the resistance of 70:30 copper-nickel alloy to sea water corrosion. Tests included the resistance to impingement attack in moving sea water containing air bubbles, and the corrosion at shielded areas under conditions of rapid water movement, and the resistance to attack under deposits in stagnant conditions. The addition of 1-2 iron greatly improved the resistance to corrosion of alloys of low nickel content and alloys containing 5-10 nickel gave excellent performances. The resistance to corrosion was affected by the heat-treatment given. These alloys are readily workable, both hot and cold, provided precautions are taken in heat-treatment. A comparison is made of copper-nickel-iron alloys with standard materials used in condenser systems. Photomicrographs. 22 references.—INCO.

6.3.6, 2.3.4

The Corrosion of Copper and of Metals in Bi-Metallic Systems. George Richard Hill. Presented, at a meeting of Western Region, National Association of Corrosion Engineers, Los Angeles, Cal., November 9, 1951. *Corrosion,* **8,** No. 5, 188-191 (1952) May.

Results of experiments in the Fuel Technology Department of the University of Utah into the kinetics of the initial corrosion of copper in aerated salt solutions are given. These show the quick formation of a film inhibits corrosion of copper. Theoretical considerations involved in the corrosion of an iron-copper couple are explained.

6.3.6, 1.6, 2.1.2

ASTM Standards on Copper and Copper Alloys. Brochure, Jan., 1951, 530 pp. Obtainable from American Society for Testing Materials, 1916 Race Street, Philadelphia, Pa. Price paper covered $4.35; cloth $5.

This brings together 108 ASTM Standards, including all those dealing with copper and its alloys and their products, as well as a number dealing with other non-ferrous metals, test methods and recommended practices.—BNF.

6.3.6, 3.5.8

The Resistance of Aluminum and Berryllium Bronzes to Fatigue and Corrosion-Fatigue. D. G. Sopwith. Ministry of Supply Aeronautical Research Council Reports and Memoranda, No. 2486, 1950, 10 pp. H. M. S. O. 2s.

This work is actually dated 1940 (published 1950). Tests of fatigue and corrosion-fatigue resistance of aluminum bronze D.T.D. 160 (copper-9.3% aluminum) and beryllium bronze (copper-2.25% beryllium) showed that heat treatment had no marked effect. The fatigue strength in air of the beryllium bronze was almost independent of the ultimate stress, which varied from 32 to 81 tons per square inch.—BNF.

6.3.6, 4.4.3

Study on the Methanol Corrosion of Copper by Electron Diffraction. S. Ogawa and D. Watanabe. *Science Reports Research Institutes,* Tôhoku Univ. (A), **2,** No. 3, 462-470 (1950) June.

Corrosion products formed on Japanese copper (99.82 copper) and American copper (99.92 copper) surfaces in methanol were copper oxides. Japanese copper was more severely corroded, and had a lead-gray appearance. Cupric oxide is readily formed after a short period of immersion. No corrosion occurred on the surfaces of the copper when immersed in dehydrated methanol. Hence, the corrosion is due to water absorbed by the methanol.—INCO.

6.3.9, 6.3.15, 6.3.20

The New Metals—Molybdenum, Titanium and Zirconium. *Welding J.* (N.Y.), **29,** 321-322 (1950) Apr.; *Industrial Gas,* **27,** 16 (1950) Apr.

Physical and mechanical properties, corrosion resistance, weldability, etc.—MR.

6.3.10, 4.3.2

Metallic (Nickel) Alloys Resistant to Hydrochloric Acid Media. (In Russian.) N. I. Gel'perin, Yu. P. Aronson, D. I. Drukarova, and T. S. Raitsina. *Zhur. Priklad.Khim.* (J. Applied Chem. USSR), **22,** No. 1, 45-55 (1949).

Summarizes published information on the mechanical properties, corrosion-resistance, heat-treatment, etc., of nickel-molybdenum-iron alloys and the Hastelloys, and describes the development of a Russian Hastelloy A-type alloy containing nickel 61, molybdenum 23, manganese 0·73, silicon 0·27, carbon 0·02 percent, balance iron. After heat-treatment at 1050° C for 5 minutes and quenching in water, the mechanical properties of the hot-rolled alloy in the longitudinal and transverse directions, respectively, were: tensile strength (σ_b) 90·8, 93·8 kg./mm.^{2}; yield point (σ_s) 48·3, 49·5 kg./mm.^{2}; extension (ε) 27·1, 20·7 percent; hardness (R_c) (26, 26, 27), (19, 21, 22). Without heat-treatment the values were: σ_b 105·9, 110 kg./mm.^{2}; σ_s 91·8, 97·2 kg./mm.^{2}; ε 19·4, 14·1 percent; R_c (28, 29, 31), (34, 35, 34). Metallographic examination showed that the alloy had a two-phase structure comprising a matrix of austen-

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itic grains with irregularly-distributed grains of some intermetallic compound; heat-treatment brought much of this second phase into solid solution and improved the corrosion-resistance and plasticity. Tables and graphs are given showing the results of loss-in-weight tests in hydrochloric acid, hydrobromic acid and formic acid. Taking a loss of 1·0 g./m.²/hr. as the max. permissible for a "resistant" alloy, the alloy described can be used with hydrochloric acid of any concentration at temp. up to 70° C, and with formic acid of any concentration at temp. up to 100° C (corrosion in this case is less at 100° C than at 50° C). With hydrobromic acid, only the 20 percent acid at 100° C caused significant attack; in hydrochloric acid also the attack was a maximum with acids of 15-20 percent concentration. Corrosion tests were also carried out in acetic acid, sulfuric acid, alkali and hydrochloric acid containing thiourea.—MA.

6.3.10, 4.3.2

Effects of Various Elements on the Hydrochloric Acid Resistivity. H. ENDO AND S. ISHIHARA. *Science Reports of the Research Institutes,* Tôhoku University, Series A, **2,** No. 4, 632-636 (1950) Aug.

Various elements were added to a number of nickel-molybdenum-chromium alloys (18-69 nickel, 4-40 molybdenum, 0-32 chromium) and their effect on the resistance to hydrochloric acid was determined. Ferro-vanadium was most effective. The 30 Mo-15 Cr-0, 5Fe-V-54.5 Ni alloy gave excellent resistance to 10 percent hydrochloric acid at room temperature. Ferro-tantalum, ferro-zirconium, copper-beryllium, tungsten, cobalt and copper had a slight effect on the resistance of the alloys. Under certain conditions ferro-tantalum gave unfavorable results. Ferro-titanium was defective in all cases.—INCO.

6.3.13, 6.3.16, 6.3.9, 3.5.1

Some Properties of Tantalum-Rich Alloys With Wolfram and Molybdenum. RUPERT H. MYERS. *Metallurgia,* **42,** 3-9 (1950) June.

Effects of tungsten and molybdenum on workability, ultimate tensile strength, hardness, electrical resistivity, work hardening rate, elongation rate, oxidation resistance and temperature required for annealing.—MR.

6.3.14, 4.3.2

Studies on the Corrosion of Tin. I—Corrosion in Hydrochloric Acid. II—Corrosion in Sulfuric Acid Solution. III—Corrosion in Nitric Acid Solution. H. ENDO AND G. YOKOYAMA. *Science Reports of the Research Institute,* Tôhoku University, Series A, **2,** No. 3, 449-455, 456-461 (1950); Series A, No. 4, 637-644 (1950) Aug.

Tin is passive in hydrochloric acid below 0.01 percent concentration. Depolarizing corrosion increases with concentration from 0.01-3.0 percent, is complete from 3-15 percent, and hydrogen evolves from 15-25%. Oxidizing agents increase the corrosion rate, but the influence of stirring is small. Corrosion of tin in 5-30 percent sulfuric acid is the depolarizing type and increases rapidly above 80 percent. Stirring, increasing temperature and oxidizing agents increase the rate, while small additions of reducing agents decrease the rate. 30 percent sulfuric acid plus 20 percent hydrochloric acid increases the corrosion rate, but not linearly. The maximum corrosion is at 35 percent nitric acid. Corrosion of tin in 10 percent and 64.5 nitric acid decreased at temperatures from 20°-30° C, increased sharply above 30° C, and did not corrode at —30° C. The addition of a neutral salt and an oxidizing agent decreased the corrosion slightly. Corrosion curves are given for the 3 acids.—INCO.

6.3.15, 1.4

Bibliography on Titanium Metal and Alloys (1946-1950): Properties, Fabrication, Uses. J. W. MEIER. Can. Dept. Mines & Tech. Surveys, Mines Branch, Phys. Met. Div. Inf. Memo. No. 303, 1950, 17 pp.

Divided into sections on books, symposia and bibliographies; properties and fabrication; alloys; general articles. Under each heading the references are arranged alphabetically by author. No abstracts.—BNF.

6.3.15, 3.7.4

A Study of Some Alloys of Titanium in the Manufacture of Which Commercial Titanium Hydrite Powder Was Used. W. E. KUHN, H. V. KINSEY, AND O. W. ELLIS. *Can. Mining Met. Bull.,* **43,** 74-87 (1950) Feb.; *Trans. Can. Inst. Mining Met.,* **53,** 54-67 (1950).

Deals with binary alloys of titanium, containing up to about 10 percent chromium, cobalt, iron, manganese, molybdenum, nickel and tungsten. Method of production; results of transverse strength, tensile and creep rupture tests; forgeability tests; metallography, deformation and microstructure; and oxidation resistance.—MR.

6.3.15

Hand Book on Titanium Metal. Published by the Titanium Metals Corporation of America, 60 East 42nd Street, New York 17, N. Y. Brochure, 1950, 72 pp.

A comprehensive and informative booklet. Discusses the metal, its production and availability; alloys; physical and mechanical properties; chemical and corrosion properties; testing procedures; fabricating and processing practices; U. S. prices for sheet, plate, strip, wire, forgings and bars.—BNF.

6.3.18

Pure Vanadium Now in Limited Production. *Iron Age,* **166,** 95-96 (1950) Oct. 5.

Method of production, fabrication and properties of 99.8 percent pure ductile vanadium now commercially available in the form of ingots, springs, rings, tubes.—MR.

6.3.19, 4.3.6, 3.4.7

The Behaviour of Zinc in Acid Electrolytes. G. MASING AND G. MOLDEHNKE. *Z. Metalkunde,* **41,** No. 11, 406-412 (1950) Nov. (In German).

Investigation of the influence of pH and aeration on the potential of 99.998 percent zinc in sodium chloride and sodium sulfate solutions.—BNF.

6.4 Non-Ferrous Metals and Alloys—Light

6.4.1, 8.9.5

Aluminum Hatch Covers. *Light Metals Bull.,* **13,** No. 3, 101 (1951).

The Etablissements MacGregor Comarain, of Neuilly, have about a year ago taken up the construction of light-alloy hatch covers. A short illustrated description is given of the different types of covers which they have supplied for use on the Liberte and Kairouan liners and for the goods and luggage holds of a new vessel being built by the Chantiers Ziegler Freres at Dunkirk for the Compagnie Generale Transatlantique. Light weight and the consequent easy handling are an important advantage of these covers. Steel fittings which are still used are protected by zinc spraying or galvanizing. Light-alloy fittings are now being introduced and will result in an additional saving in weight of 4 to 5 percent.—TIME.

6.4.2, 1.2.1

Aluminum Is Not Injurious to Health. (Aluminium ist nicht gesundheits-schadlich). W. VON ZWEHL. *Eberswalder Offertenblatt* (Germany), **71,** No. 22, 946-947 (1950) Nov. 25.

Aluminum utensils offer the advantages of easy cleaning, good heat conductivity, long life and unobjectionable hygienic behavior. This last property has been the subject of hundreds of investigations in many countries. Since about 8 percent of the earth's surface consists of aluminum, water and most raw foods contain traces of aluminum. The aluminum content of food is increased somewhat when cooked or preserved in aluminum utensils, yet the resulting average daily increase in aluminum intake is less than the aluminum content of an egg. Tests with humans and with animals have proved that a 100-fold increase in the normal daily consumption of aluminum does not harm the body. Therefore, there is no question about the fact that the small amount of aluminum introduced into the body from aluminum utensils must be harmless. Results of studies by German and American investigators give no indication that the vitamin C content of milk is destroyed by cooking in aluminum utensils. Since aluminum is non-poisonous, it is used widely in the treatment of wounds, burns and infectious ulcers.—ALL.

6.4.2, 4.6.11, 8.9.5

Marine Exposure of Aluminium. *Light Metals Bull.,* **13,** No. 2, 63 (1951).

A recent article in Light Metals gives several examples of the application of aluminum in ships of many types, warships, cargo ships and smaller craft. The common alloy is that containing 3½ percent magnesium, the 5 percent alloy having many, and the 7 percent fewer, applications. Results are given of corrosion tests by the Aluminum Company of America on specimens of some other aluminum alloys. All those tested showed excellent resistance to corrosion in sea and harbor waters. In many cases there was actually an increase in the tensile strength of the material after exposure, presumably due to ageing, and where there was a loss of strength it seldom amounted to more than a few percent even after two years' immersion.—TIME.

6.4.2, 5.4.2, 3.5.3

New Hard Coating Gains Wear Applications for Aluminum. *Materials & Methods,* **32,** No. 2, 62-64 (1950) Aug.

A recently developed hard coating applied electrochemically to aluminum and its alloys is designated as MHC finish and makes light weight aluminum applicable to structures requiring high scratch and wear resistance that for-

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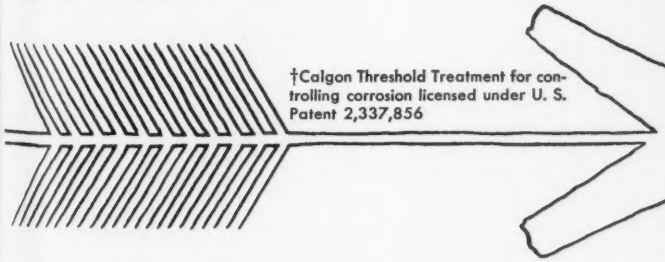

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merly needed alloy steels. The properties of MHC finish suggest that it is basically a film of aluminum oxide. The coating produces a gray, file-hard, nonmetallic, highly heat-refractive surface that is integrally bonded to the base metal. Coating thicknesses range from 0.0001 to 0.006 in.; 0.0002 in. is used for most applications. This is thicker than anodized film which ranges from 0.0001 to 0.0008 in.

The most significant property of this coating is its abrasion resistance, which exceeds that of cyanide case-hardened steel. The cofficient of friction is probably lower than that of the untreated metal; molybdenum sulfide or graphite are preferred lubricants. The coating has good impact resistance. The finish also causes a marked drop in the endurance limit of the metal. It is a nonconductor of electricity, and thus serves as a good insulator. At temperatures over 200° F. the film will check, because of the difference in coefficient of expansion of the aluminum and the hard coating. The checking, however, does not materially impair corrosion resistance. The coating has excellent resistance to atmospheric and salt water corrosion but is attacked by strong acids and alkalies.

The electrochemical process, which is carried out as a final step after all machining, grinding, and related operations have been completed, permits irregular shapes to be uniformly coated. On a production scale the coating is expected to be cheaper than hard chromium plating. The saving in weight through this treatment is of particular value in aircraft construction.

6.4.2, 8.1.2

Aluminium Roofs (Toits; Dächer). Published by L'Aluminium Commercial S. A., Zurich (Switzerland) 48 pages, 1951.

The history of the use of aluminum roofing is traced from its first application on the cupola of the church of San Gioacchino in Rome in 1897. The advantages of aluminum roofing are discussed from the aspect of color, corrosion resistance, light and heat reflectivity, fire protection, ease in painting, light weight, cheap and easy transportation, no maintenance, variety of application combination with aluminum fittings, no breakage, no waste, non-toxicity and freedom from vermin, insects and fungi. The methods of fitting aluminum sheet, corrugated sheet, roof plates, tiles, shingles, and the standing seam roof are described and illustrated by photographs. The text is extensively illustrated throughout by photographs of applications of aluminum roofing.—ALL.

6.4.2, 8.3.5, 3.4.6

The Corrosion of Aluminium-Low Temperature Station Carries Out Research. *Chem. Age* (London), **64,** No. 1660, 711-713 (1951) May.

The Food Investigation Organization of the British Government is investigating the corrosion of aluminum at its Low Temperature Research Station for research in biochemistry and biophysics, at Cambridge. The research program is being carried out in three stages. Work on the first phase started in 1933, and involved a thorough review of the literature. The second stage was devoted to research in the corrosion of aluminum to fill some of the gaps revealed by this summary. A third phase is the application of previous research in devising methods of protecting aluminum from corrosion by foods and beverages. J. M. Bryan gave an account of the work covered, which is mostly a study of the effect of various factors, such as the purity of the metal, temperature, pH, presence of salts, presence of oxygen, etc. on corrosion. The theory of corrosion of aluminum is discussed in some detail. The corrosion is largely a film problem and bears some relation to the physical and chemical properties of alumina. The role of dissolved oxygen in corrosion is of special interest, because it can act as an accelerator or as an inhibitor of corrosion. An iodine test was devised using an aqueous solution of iodine and potassium iodide which readily attacks exposed metallic aluminum, but has much less action on the oxide and on parts covered by oxide. It was established that boiling water reacts with aluminum initially with the evolution of hydrogen and the formation of a protective film which soon checks further action. This was not true, however, in a sample of super-pure aluminum containing almost no silicon. Since the inhibiting action of small amounts of silicate in solution is well known, it was suspected that the continued corrosion of the super pure aluminum was due to the lack of silicon. Further support for this view was provided by a test which showed that the action of boiling water could be almost entirely prevented by the addition of 0.05 percent or more of pure dialysed silica to the water. It was estimated that the water-formed films on ordinary aluminum reach a maximum thickness of about 4×10^{-5} cm., and anodic films, the thickness of which ranges from about 2.5×10^{-4}, to 2.5×10^{-3} cm.

An alternative test to the iodine for roughly assessing the decline in reactivity of film-free aluminum during washing in various liquids consists of immersing the metal in a saturated solution of copper sulfate and observing the rate and amount of copper deposited. Film-free aluminum brings about rapid reduction and copious deposition of copper, whereas unetched aluminum is relatively inert. The research work in progress now is the improvement of the process for the direct plating of aluminum with nickel.—ALL.

6.4.2, 4.3.6

The Behavior of Copper-Containing Aluminum in Common Salt Solutions. (In German.) Doris Kuhlmann-Wilsdorf and Georg Masing. *Z. Metallkunde,* **42,** 497-503 (1950) Dec.

Corrosion tests on aluminum alloys with 0.6.64 percent copper, annealed and quenched from 500° C; in buffered sodium chloride solutions, show that stationary potential of the alloys increases in nobility with the copper content of the solid solutions and that copper, after dissolving with solid solutions, precipitates again. Includes photomicrographs, tables and graphs.—BLR.

6.4.2

Non-Heat-Treatable Wrought Aluminum Alloys. *Materials & Methods,* **31,** 83 (1950) Mar.

Data sheet covers compositions; physical properties; mechanical properties; annealing temperature; hot-working temperature range; machinability; relative torch, inert-arc, and resistance weldability; resistance to atmospheric and chemical corrosion; available forms; and uses of 2S, 3S, 4S, 52S, and 56S alloys.—MR.

6.4.2, 2.2.2, 2.2.6

Durability of Aluminum and its Alloys: Atmospheric Exposure. *Light Metals* (England), **13,** Nos. 150 & 151, 395-402, 429-438 (1950) July, Aug.

Summary of tests mainly carried out by ASTM and Alcoa. Atmospheric corrosion of aluminum and aluminum alloys compares favorably with other nonferrous metals, including copper-base materials, nickel, Monel, zinc, tin, lead and lead-antimony alloy. Account of specific uses of aluminum and its alloys where resistance to corrosion is a main factor; soil corrosion tests.

6.4.2, 3.5.9

Aluminum—6 Per Cent Magnesium Alloys for Elevated-Temperature Service. L. W. Eastwood, Webster Hodge and C. H. Lorig. *Proc. Am. Soc. Testing Materials,* **50,** 1013-1034 (1950).

Describes composition, physical and mechanical properties, corrosion resistance and machinability of an alloy of the above type which was developed as a result of a systematic study of aluminum-base alloys containing magnesium. The alloy contains 6% magnesium, 1.5% copper, 1% manganese, 0.19% vanadium, 0.05-0.25% zirconium, 0.08% titanium and 0.005% beryllium. Good corrosion-resistance, machining, tensile and creep properties are claimed.

6.4.2, 8.1.2

Aluminum Insulated Roofing for Farm Buildings. *Sheet Metal Worker,* **41,** 35, 39 (1950) Aug.

An installation on a large poultry farm. Results of temperature studies in comparison with noninsulated chicken houses.—MR.

6.4.2, 3.5.4, 5.9.4

From a Metallurgist's Notebook: Anodized Aluminum. H. H. Symmonds. *Metal Ind.* (London), **76,** 345-346 (1950) May 5.

Fading of an anodized aluminum panel was believed to be caused by the action of sunshine or effects of abrasion on cleaning. Tests were carried out on similar plates to examine fading after exposure to ultraviolet radiation of varying intensity. Conclusions as to the behavior of various finishes on such panels under these conditions. 18th report of series.—MR.

6.4.2, 8.3.5

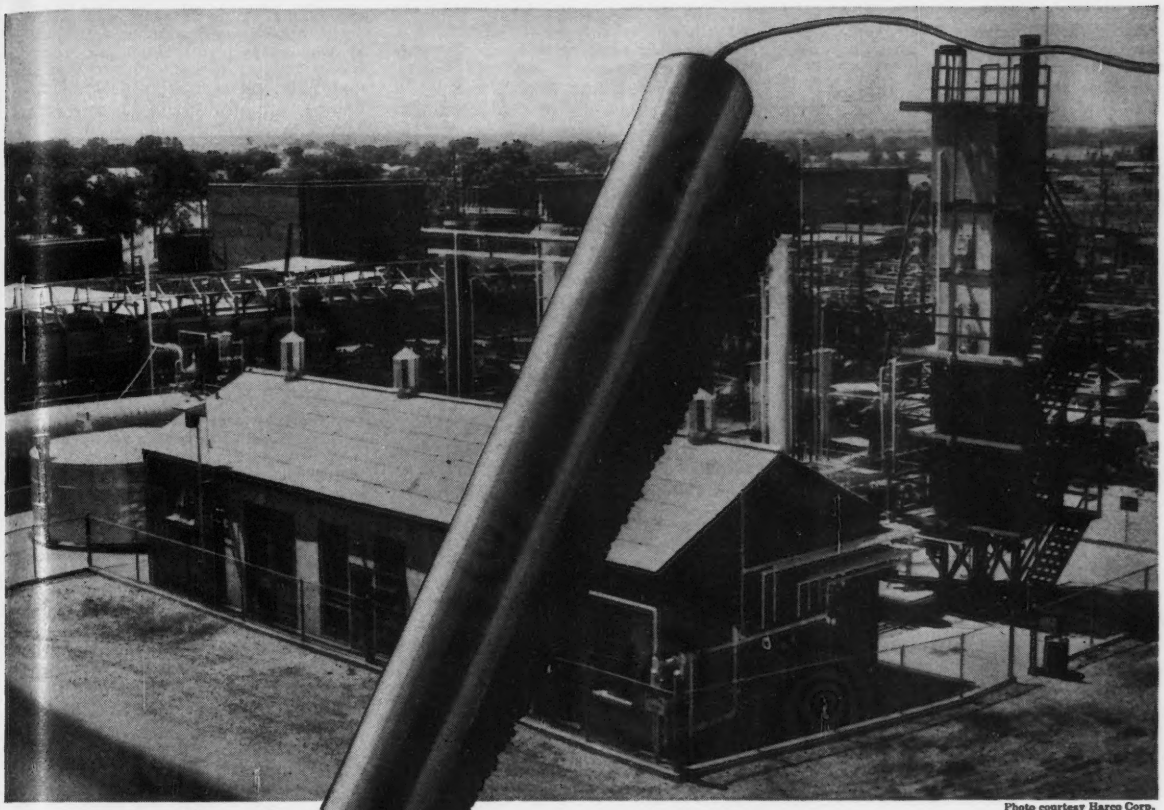
Aluminum's Next Big Target: The Container Industry. *Modern Metals,* **6,** No. 9, 36-39 (1950) Oct.

Advantages claimed for aluminum as a container material include its nontoxicity, light weight, attractive appearance, ease of working, etc. It is considered that aluminum has a wide application in this field. Various difficulties have been overcome. Distortion during sterilization has been largely overcome by use of over-pressure autoclaves; the seam problem has been lessened by the use of cold welding or alternatively by the use of sandwich welds; internal corrosion troubles have been eased by the use of continuous anodizing processes.—MA.

6.4.4, 2.3.7, 8.9.1

Mg Gets "Third Degree." *Steel,* **127,** 146, 148 (1950) Oct. 16.

Results of extensive stress-corrosion tests conducted to determine magnesium's suitability for aircraft use.—MR.



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6.4.4, 6.4.3, 3.4.6

Action of Anhydrous Hydrogen Chloride Gas on Beryllium, Magnesium, and Their Oxides. (In French.) JEAN BESSON. *Bull. soc. chim. France,* **1950,** 1175-1179, Nov.-Dec.

Action of hydrochloric acid gas on above and their oxides as well as on alkaline-earth metals, mercury, zinc, and cadmium at temperatures up to 1000° C was investigated. Beryllium, magnesium, zinc, and cadmium form at ordinary temperatures chloride films which protect the metal from further attack by hydrogen chloride gas. This protective action disappears at the fusion point of the chloride layer. 12 ref.—BLR.

6.4.4, 7.10

The Applications of Magnesium Alloys in Optical Instruments. E. NEUKIRCH. *Metall,* **4,** Nos. 7-8, 142-144 (1950).

A brief review. Emphasis is placed on the importance of using pure metals in the preparation of the alloys, the rigid adherence to impurity limits, the use of heliarc welding for fabrication, and proper surface treatment of the articles to render them highly resistant to corrosion. 18 references.—MA.

6.6 Non-Metallic Materials

6.6.6, 7.1

Ceramics—A Survey of Their Possibilities as Gas-Turbine Blade Material. T. G. CARRUTHERS AND A. L. ROBERTS. *Aircraft Prod.* (England), **13,** No. 149, 88-91 (1951) Mar.

The main disadvantages of ceramic materials for use in gas-turbines are absence of ductility, sensitivity to thermal shock, and low impact strength. Available data on the mechanical properties of possible ceramic turbine materials including aluminum oxide, beryllium oxide, magnesium oxide, zirconium dioxide, thorium dioxide, and Mg $O.Al_2O_3$ (spine) are tabulated. The data suggest that certain materials, particularly the single-component type, are potentially suitable for use in turbine blades for operation at temperatures up to 1000° C. (1832° F.), provided that operating conditions are such as to minimize thermal shock. The use of single-component materials is precluded in intermittently-operated engines because of the lack of resistance to thermal shock. Possible methods for improving this property are under study. Multi-component ceramics offer more scope for increasing thermal shock resistance, but the availability of raw materials and manufacturing problems are serious difficulties. It is believed that substantial improvements in sintered-oxide ceramics are still possible.—ALL.

6.6.7, 5.4.7, 8.9.5

Use of Flame-Sprayed Polysulphide Coatings and New Methods of Application. E. A. BUKZIN. *Rubber Age* (N. Y.), **67,** 681-684 (1950).

Methods of preventing underwater corrosion and erosion of steel propeller struts and rudders are described. Powdered polysulphide rubber containing small amounts of vulcanizing agents is flame-sprayed to give a tough elastic coating which adheres well to steel and can be patched readily.—RPI.

6.6.8, 8.9.1

Metal Adhesives for Bonding Aircraft Assemblies. *Automotive and Aviation Inds.,* **103,** No. 3, 38-40+ (1950) Aug.

'Metlbond' is the trade name for a metal-bonding process, in which two adhesives are applied in separate layers. The process has been used primarily on magnesium alloys and on clad aluminum alloys, but with proper processing conditions is probably applicable to other metals, thermosetting plastics, and wood. One of the adhesives, M3C, is flexible and establishes a bond with the metal surface; the other adhesive, N2, is thermoplastic before curing and serves to equalize pressures by filling in small surface irregularities.

The process produces a bond that develops adequate shear strength and flexibility, and gives good surface protection. The adhesives are resistant to fungi, high humidity, and temperature changes from 165 to —75° F. Bonded joints show excellent resistance to fatigue, and to normal cleaning compounds, fuels, and oils. Metlbonded assemblies are easily installed because they are simple in shape and have doublers at attachment points.

A shear stress of 3000 psi is typical for unprimed clad aluminum alloys bonded to bare 0.064-in. clad 24S-T aluminum alloy standard test panels with 0.5-in. overlap. A value of 1400 psi is typical for primed magesium bonded to 0.064-in. Fs-1h magnesium alloy standard panels with 0.5-in. overlap. Minimum required values are 2500 and 750 psi, respectively.

Metlbond adhesives, originally applied by spraying, are now deposited on a thin fabric base, thus avoiding most of the spraying and all of the oven-drying formerly necessary. This dry-film method of application makes possible the manufacture of aircraft parts on a high production assembly basis. Metlbond film used by Convair is made from nylon parachute cloth 1 ft. wide, which is dipped in N2 adhesive, and heat-dried, Another commercial film has a Fiberglas cloth base and is available in widths varying from less than 1 in. to 36 in. The films when applied are sufficiently tacky to adhere to faying surfaces. Curing conditions for bonding are not critical; usually 320-350° F. for 25-35 minutes is sufficient.—PDA.

6.6.8, 5.6.2

Moisture-Proof Wrapping. E. E. HALLS. *Food,* **19,** No. 226, 258-259; No. 227, 306-310; No. 129, 376-378, 386; No. 231, 469-472 (1950).

A review of physical, mechanical and chemical properties of various plastic films. Moisture permeability, bursting strengths, etc., are tabulated. The availability of the materials is also discussed. —RPI.

6.6.8, 3.4.1

Chemical Attack on Polymeric Materials as Modified by Diffusion. S. M. KATZ, E. T. KUBU AND J. H. WAKELIN. *Textile Research J.,* **20,** 754-760 (1950).

The reaction of polymeric media with a chemical reagent generally involves the preliminary diffusion of the reagent through the polymer. An equation for the effect of a relatively rapid diffusion of a chemical reagent into a cylindrical fiber on the over-all rate of reaction is derived.—RPI.

6.6.8

Soft Plastic Materials for Corrosion Protection. HJ. SAECHTLIN. *Werkstoffe u. Korrosion,* **1,** Nos. 6/7, 251-253 (1950).

The resistance of polyvinyl chloride-type plastics to corrosion by several acids, alkalies and aqueous salt solutions at various concentrations and temperatures is described and the uses of such materials for corrosion protection, e.g. linings, are discussed. 12 references.—MA.

7. EQUIPMENT

7.1 Engines, Bearings and Turbines

7.1, 2.3.7, 6.2.5

New Technique for Obtaining Heat-Transfer Parameters of the Wall and Combustion Gas in a Rocket Motor. M. E. ELLION. *Trans. Am. Soc. Mech. Engs.,* **73,** 109-114 (1951) Feb.

Describes test method for obtaining gas sidewall temperatures in a rocket motor in order to evaluate suitability of various alloys for rocket motor construction. Eight alloys were studied by use of a thick-walled water-cooled nozzle into which cylindrical specimens could be inserted. A modification of this technique is suggested for measuring combustion-gas film coefficient in rocket motors. The alloys were Armco iron; SAE-1010; Types 347, 446 and 310 stainless; 61S-T Al, Type "A" Ni; Inconel X; and Cu. Oxidation characteristics were observed.—BLR.

7.1, 5.1

Corrosion of Oil Engine Parts. *Oil Engine,* **18,** No. 205, 36-37 (1950) May.

The factors which cause corrosion, dangers of cold conditions, harmful lubricants, oxidation of surfaces and corrosion during shutdown periods are discussed briefly. Corrosion preventives are described generally.

7.1, 5.11

Research, Design and Development Problems in Gas Turbines. J. F. SHANNON. *Trans. Inst. Engrs. Shipbuilders* (Scotland), **94,** pt. 3, 132-159 (1950-1951).

The problems discussed and referred to are blade variation, stalling flutter of compressor blades, strain gaging and temperature measurement, the combustion chamber, blade and disc cooling, thermal shock and corrosion arising from residual fuels of high ash content. 17 references.—BLR.

7.2 Valves, Pipes and Meters

7.2

A Technique for Salvaging Pipe Under Street Crossings. BUFORD P. LEDBETTER AND HUGH WILBANKS, JR. Gas Department, City of Corpus Christi. Presented at a meeting of South Central Region, National Association of Corrosion Engineers, Corpus Christi, Texas, October 18-19, 1951, under the title "Operation Tamale." *Corrosion,* **8,** No. 5, 185-187 (1952) May.

A description is given of a method of removing 750 feet of 6-inch and 8-inch wrapped steel gas main from beneath street crossings without cutting the street. A burner placed in one end of pipe under streets heated it to the flow point of the coal tar enamels coating when, with a winch line, the pipe was pulled out of its felt wrapper like a tamale slid out of its husk, using the melted coal tar enamel as a lubricant.

This procedure permitted recovery of

pipe which could not have been saved economically otherwise. Details of technique are given and operations are illustrated with photographs.

Inspection of coating on removed pipe indicates application of coal tar enamel in excess of 3/32-inch in the type of soil encountered would be of very little value.

7.2, 3.7.3, 6.7.3

Welds Between Dissimilar Alloys in Full-Size Steam Piping. R. Ul. Blaser, E. Eberle and J. T. Tucker, Jr., *Proc. Am. Soc. Testing Materials*, **50**, 789-808, disc., p. 858-860 (1950).

Factors affecting the safe operation of ferritic-austenitic weld joints in large-size steam piping were studied by means of a simulated proof test. The specimen consisted of a 10¾-inch diameter section of 2¼ chromium-1 molybdenum steam pipe welded to end pieces of 18 chromium-8 nickel-niobium (columbium) wrought and 16 chromium-13 nickel-2 molybdenum-niobium (columbium) cast materials, using 19 chromium-9 nickel-niobium (columbium) welding electrodes. Cracks were detected by radiographic means in the pipe at the edge of the weld after 4631 hours at 1100° F. and 1500 psi., involving 47 shutdowns to atmospheric conditions. Metallurgical examination showed the principal factors contributing failure.—BLR.

7.2, 6.4.2

Diaphragm Valve of New Design. *Light Metals* (England), **13**, 334-335 (1950) June.

Valve recommended for use in pipelines carrying liquids such as fruit juices, milk, etc., where glasslined or bronze valves are commonly used. Includes long list of fluids for which aluminum valve bodies are suitable, also a shorter list for which aluminum is not recommended.—MR.

7.2, 6.3.6, 3.2.2

Copper Water Pipes; Result of B.N.F.M.R.A. Investigation on Corrosion. *Metal Ind.* (London), **76**, 129-130 (1950) Feb. 17.

Cause of occasional pitting was traced to carbonaceous films produced on the pipes during the manufacturing operation. Occurrence of these films can easily be prevented and the pitting thus avoided. —MR.

8. INDUSTRIES

8.1 Group 1

8.1.2, 3.4.1

Examples of Chemical Damage to Structures. (Einige Beispiele chemischer Bauschäden). A. Leon. *Werkstoffe u. Korrosion* (Germany), **1**, No. 12, 473-476 (1950) Dec.

Some of the cases of damage to brickwork, masonry, concrete, roofing and aluminum insulating materials caused by chemical reactions which were investigated by the building department of the Technische Hochschule Wien are discussed. Usually, the conditions causing the damage result from carelessness or lack of knowledge. In one instance, calcium hydrate given off from setting concrete was brought in contact with aluminum foil insulation by rainwater and the foil corroded through. The condition was aggravated by the bitumen which contained cresole, phenol and sulfuric acid. A third factor contributing to the corrosion was the use of iron or gal-

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vanized nails which, in combination with the water, led to pitting. Investigations have shown that aluminum slag should not be added in the production of concrete. The slag contains aluminum, alumina and cryolite. The resulting emission of hydrogen would destroy the structure of the concrete and weaken it.—ALL.

8.1.2, 3.4.9

A Study of the Corrosion of Galvanized Iron Roofing in Contact with Moist Building Materials, Earth, Clay, and Sand. F. M. IVANOV. (In Russian.) *J. Applied Chem.* (U.S.S.R.), **23,** No. 8, 896 (1950).

Criticism of a paper by Solov'ev. The figures given for 11 of the 18 materials examined do not correspond with behavior in practice, because of the incorrect experimental conditions employed. The crushing of brick, mortar, etc., would result in excessive contact with moisture and air, the periodic moistening (once every 24 hr.) would result in different testing conditions for different materials, owing to the variation in drying rate. Moistening must have changed the clay into a paste. The results for Portland cement/sand mortar are not in agreement with experience concerning reinforced concrete.—MA.

8.1.2, 5.3.4, 6.2.3

Zinc Coatings, Especially for Constructional Steelwork. (Met verzinken in het bijzonder van staalconstructies.) Publication by N. V. Plaatwerkerij en Verzinkerij v/h P. Bammens & Zn. Maarssen. 3rd Edn. 1950. (In Dutch). 7 illus. 19 pp.

A review of the various methods used for protecting steel from rust, with special reference to steel constructions. After remarks on the increase of general interest in this subject, and the absence of technical literature, the 4 usual methods of applying zinc coatings are discussed in some detail, viz.: hot dip galvanizing; electro-plating; Sherardizing; and zinc spraying. The author concludes that, in general, hot dip galvanizing is the best and cheapest procedure and will therefore carry a wider appeal than other zinc coating methods.—ZDA.

8.1.4, 7.2, 6.3.8

Some Basic Considerations With Respect to Formation of Protective Layers on Lead and on Solubility of Lead in Drinking Water. (In German.) JOHANNES MULLER. *Gas-u. Wasserfach.,* **92,** 39-42 (1951) Feb. 28.

Discusses pros and cons of using lead pipes for drinking water lines. Considers differences between protective layers on lead and iron. Reactions of water with the lead and with coatings which form on the inside of the pipes, also suspensions of lead compounds and their reactions with cations present in the water, as well as importance of the absence of porosity in the protective layers are discussed. 12 references.—BLR.

8.2 Group 2

8.2.2, 3.4.6, 4.6.2

Prevention of Standby Corrosion in Power Plants. LEONARD HIGHLEY, JR. AND W. R. SCHNARRENBERGER. *Corrosion,* **8,** No. 5, 171-177 (1952) May.

It is common practice in taking a boiler off the line to do no more than let the fire burn out and allow the water in the unit to assume its natural level. This practice is frequently adopted so the boiler can be placed in service again on short notice. However, if immediate need for the boiler is not anticipated, it is preferable to prepare the unit so that corrosion cannot occur during the idle period, when the boiler is in standby.

Recognizing standby corrosion and distinguishing between it and corrosion occurring during operation are often difficult tasks and require considerable experience on the part of the boiler inspector or plant operator. Specific locations in the boiler are especially susceptible to attack during standby, but under certain conditions any area in the unit may be affected.

A number of case histories are cited to illustrate the complexity of the problem. These describe damage to boilers, superheaters and turbines—vital units of power plant equipment. Reference is made to the pertinent points which establish the fact corrosion occurred during periods of standby.

A number of practical preventive measures are described which have proved effective in practice. These include both dry and wet procedures. For boilers and superheaters the dry method provides the most certain protection. Dry standby entails draining the boiler and keeping it dry during the idle period. When the wet method is used it is essential that the unit be completely filled with properly conditioned water at all times and that circulation be supplied at intervals to insure against dilution resulting from leakage of feedwater or steam condensate into the unit.

Standby protection in the case of turbines will usually involve guarding against steam in-leakage and prevention of siphoning action through drain lines.

Basically, prevention of standby corrosion requires keeping all surfaces of equipment free from contact with moist air or water containing dissolved oxygen. While operating requirements of industrial power plants will vary, suggested procedures will nevertheless serve as guides in preventing standby corrosion.

8.3 Group 3

8.3.1, 6.2.3, 4.5.1

Study of Wear of Steel Against Soil. II. (In Japanese.) TETSUTARO MITSUHASI, YUTAKA IMEI, AND SHIN YOKOI. *J. Mechanical Laboratory,* **4,** 291-298 (1950) Dec.

Results of above study, made in order to improve the wear of soil-tillage parts of agricultural implements, are tabulated, charted, and summarized in English. A carbon steel was used.—BLR.

8.3.5, 7.5.2

Tin-Coated or Lacquer-Coated Food Cans. H. KETTERL. *Verpackungs-Wirtschaftl.,* No. 1, 10 (1950); *Fette u. Seifen,* **52,** No. 9, 570 (1950).

Because of the acute tin shortage, lacquered blackplate is recommended as an excellent substitute for tinplate for food cans.—RPI.

8.4 Group 4

8.4.3

Metallurgical Problems in Oil Well Drilling and Petroleum Production. GEORGE W. WHITNEY AND MORTON SPAR. *Metal Progress,* **57,** 755-760 (1950) June.

General discussion as applied to derrick equipment, power transmission, sucker rods and pumps. Largely limited to ferrous alloys and their resistances to mechanical and corrosive effects.—MR.

8.4.3

Plastics Combat Well Head Corrosion in Galveston Bay Fields. J. E. KASTROP. *World Oil,* **130,** No. 5, 162-166 (1950) Apr.

Coating well heads in Galveston Bay with vinyl resins to prevent salt-water corrosion is described.

8.4.3, 6.2.3, 4.2.5

Protection of Steel in Off-Shore Structures. F. L. LAQUE. *Drilling,* **11,** No. 8, 29-31, 102-103 (1950) June.

Corrosion of offshore drilling structure supports is divided into various zones of attack, as follows, with suggested methods of protection: mud line and area below low tide—cathodic protection below water and underground; tidal and splash zones—corrosion resistant metal sheaths; above the splash zone—organic or metallic coatings. A plot shows the extent and distribution of corrosion on a structure, as determined by Kure Beach tests.

8.4.3, 6.2.1, 6.3.1

Use of Metals and Alloys in The Petroleum Industry. M. MOINARD. Standard Francaise des Petroles. *Tech. et appl. petrole,* **5,** 1402-1408 (1950) Nov.

The corrosiveness of the various petroleum products, and the general properties required by a metal for use at high temperatures are reviewed. Specific metals and alloys, e.g. ordinary "Thomas" steel; "Martin" steel, iron, steels containing 0.5 percent copper, with or without molybdenum, chromium, aluminum; heat-resistant steels, etc.; cast irons, aluminum, lead, cuprous metals, nickel and alloys, special alloys—are considered as to their resistance to corrosion by chemicals and high temperatures, to abrasion, etc.

8.4.3, 5.3.2, 5.4.1

Protection of the Internal Surfaces of Refinery Equipment. H. MAYSLICH. Standard Francaise des Petroles. *Tech. et appl. petrole,* **5,** 1375-1388 (1950) Nov.

Techniques for protecting refinery equipment from corrosion are described, e.g. metal plating (by hot rolling, casting, arc welding, resistance welding), metallic linings (tack-welded linings, etc.), metal spraying, non-metallic linings (bricks and refractories, rubbers, Gunite, pyrex, etc.), paints, enamels and glazes.

8.4.3, 3.5.8, 6.4.4

Causes and Prevention of Drill Collar Failures. STANLEY C. MOORE. *Drilling,* **12,** 28+ (1950) Nov.

Practically all drill-collar failures noted in the field are the result of fatigue at the connections—either simple fatigue in the case of the pins, or corrosion fatigue in the case of the boxes. Recommended operating procedures and design. Use of a Mg ring in the drill-collar box to prevent corrosion in the bore near the ring, by electrochemical action.—MR.

8.5 Group 5

8.5.3

Paper-Mill Painting and Its Relation

TYGON

Versus ROH

PURE alcohols usually are not corrosive. However, under certain conditions, in aqueous solutions, or in combination with other chemicals, they can and do give trouble. Alcoholic solutions of acids and bases, tinctures, and the use of denaturants offer a complicated picture of corrosive attack. Additionally, the organic nature of alcohols warrants special consideration in their use with the TYGON family of plastic compounds.

The TYGON family is a series of vinyl based compounds — selected polyvinyl resins carefully modified with other materials to give the maximum in general chemical resistance and physical properties. There are a number of standard and special compounds available in the form of calendered or press-polished sheeting, molded goods, extrusions, paint and plastisols. Some are non-toxic, others are not. Some are glass-clear, some are glossy black, still others are available in practically any color. A wide range of physical and mechanical properties are exhibited. Many different types of applications are possible.

In any of its forms, TYGON displays excellent resistance to both simple and polybasic alcohols in any concentration. Service temperatures are limited only by the boiling points of the alcohols involved. Where alcohols are used in combination with other chemicals, preliminary tests or the counsel of U. S. Stoneware engineers is advised. In these cases, the particular additives used govern the suitability of TYGON and its service limits.

Because of the organic nature of the two materials, a certain amount of trace extraction takes place whenever TYGON is used in full contact with alcohols. The total extraction is very low — almost negligible. It usually results in a slight hardening and stiffening, a slight loss of weight and a slight color change. Generally speaking, these changes are barely noticeable and do not affect the protectability of the TYGON.

Another factor to remember in the use of TYGON with alcohols involves its use with tinctures. Occasionally, the color of the material in solution is imparted to the TYGON. Once again, however, the protectability and functioning of the TYGON is unaffected excepting where solution visibility is important.

TYGON as calendered or press-polished sheeting is used primarily to line and cover all types of process equipment. It also is die-cut into gaskets, seals, and separators for a wide variety of uses.

In molded form, TYGON has even wider application — a range of uses limited only by the size and shape that can be imparted to a thermoplastic material by mold and press.

In the form of extrusions, TYGON's major use is as flexible tubing and piping. In both plant and laboratory, strong, light, glass-clear, and fully flexible TYGON Tubing has done much to simplify the problem of transmitting corrosive liquids, gases, or semi-solids. Extruded solid cord and channel also find use as gasketing, expansion jointing, and packing.

As a paint, TYGON is used to protect equipment, structural steel, walls, and ceilings against corrosive fumes and spillage. As a plastisol, TYGON is used as a heavier duty coating and in the casting or "slush" molding of flexible parts and fittings.

For most applications, TYGON in its various forms is a very practical material for use with alcohols and mixtures of alcohols with other chemicals. Occasionally, limits may be imposed by the added chemicals or by the need for absolute purity. However, these are isolated cases. TYGON can be safely regarded as an economical and effective material of construction, medium of transmission and protective coating for use with alcohols.

TYGON plastics

In addition to TYGON in its various forms, we also manufacture a number of other materials capable of handling alcohols and their mixtures with other chemicals in any concentration and under all types of operating conditions. These products include chemical stoneware and porcelain, acid proof brick and cements, homogenous lead linings, and other organic linings and coatings.

Why don't you submit your corrosion problem today? There's no obligation and we'll be pleased to be of assistance. So write, now!

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ENGINEERS, MANUFACTURERS, ERECTORS OF CORROSION-RESISTANT EQUIPMENT SINCE 1865

to Mill Maintenance. O. F. SHOBE. *Paper Ind. and Paper World,* **32,** 529-531 (1950).

The preparation and treatment of various surfaces in the pulp and paper mill are discussed.—RPI.

8.8 Group 8

8.8.6, 8.8.1

Materials for Chemical Plant Discussed at S.C.I. Conference. *Mfg. Chemist,* **21,** No. 5, 200-203 (1950).

Report of a Conference on Materials of Construction in the Chemical Industry organized by the Society of Chemical Industry at Birmingham University, 18-20 Apr., 1950. Summaries of papers on stoneware plant, thermal insulating materials, ferrous metals, stainless steel, aluminum, lead, tin, copper and copper alloys, noble metals, rubber plastics, glass and carbon are presented, with particular reference to their applications in the pharmaceutical and fine-chemical industry.—MA.

8.9 Group 9

8.9.1, 5.4.5

Refinishing Seaplane Propellers. H. E. JACKSON. *Ind. Finishing,* **26,** No. 8, 33-34 (1950).

Seaplane propellers, which become pitted by the action of salt water, are dismantled and all paint removed from the various aluminum and iron parts. The propeller blades are filled, ground and buffed to remove all pitting, and then anodized; the steel parts are cadmium-plated. Finishing is by spraying, using a zinc chrome primer followed by 2 coats of a camouflage black enamel. Yellow markings are then sprayed on the tips of the blades.—RPI.

8.9.2, 5.4.5, 5.9.4

Finishing the Land Rover. *Product Finishing* (London), **3,** No. 12, 42-43+ (1950).

The finishing process of an aluminum steel vehicle is described, with particular reference to pre-painting, phosphating and production line handling technique. —RPI.

8.9.3

Cathodic Protection on Texas Gas System. ROBERT J. KUHN. Paper, Am. Gas Assoc., Detroit, Mich., Apr. 3-5, 1950. *Petroleum Engr.,* **22,** No. 7, D35-D36, Reference Annual (1950) July.

Details of steps taken to prevent corrosion on the 840-mile line from Texas to Ohio.—MR.

8.9.3, 1.3

Natural Gas in Ohio: A History. T. H. KERR. Engineering Experiment Station, Ohio State University, Circular 52, Sept. 1950, 116 pages.

History of five Ohio gas companies, gas measuring devices regulation, storage, pipe and underground corrosion of cast iron, wrought iron and steel pipe in different Ohio soils.—MR.

8.9.3, 2.4.3

Nondestructive Materials Testing on Pipe Lines; X-Ray Examination of Welded Pipe Joints. (In German.) WOLFGANG KOLB. *Gas-u.Wasserfach,* **91,** 247-255 (1950) Oct. 31.

Potentiometric, electromagnetic and counting-tube methods for measuring the thicknesses of tube walls. The magnetic-powder process for measuring the thicknesses of protective coatings; how specific welded-joint defects can be detected by the X-ray method. 17 references.—MR.

8.9.3, 2.4.2

Finding Coating Faults in Buried Pipe Using Pipe Locator and Pearson Method. L. F. HEVERLY. *Corrosion,* **6,** No. 10, 1 (1950) Oct.

The Great Lakes Pipe Line Co. has adopted the Wahlquist Pipe Locator as standard equipment for locating coating holidays or faults using the Pearson method.

The Pearson method is as follows: Two men with shoe cleats, walk 20 to 25 feet apart carrying 20 to 25 feet of insulated single-conductor wire between them, and a pipe locator receiver with earphones and inter-connecting leads. The pipe locator transmitter is connected to the line in the usual manner for the conductive method of locating a pipe line. As a holiday is approached by the lead man the interrupted signal grows louder and reaches a maximum, then diminishes as he passes by the holiday. The same process occurs as the second man with the receiver approaches and passes the holiday. From the above the approximate peak location can be located plus or minus a few inches.

8.9.4, 6.4.2, 5.4.5

Paint Coats on Railway Trucks Made From Aluminum (Alloy). *Ind.-Lack.-Betrieb,* **18,** No. 9, 172 (1950).

Experiments have been carried out in France and America with trucks partly built from steel plates and others in which the steel plates were replaced by aluminum-copper-magnesium alloy plates. The steel truck was wire-brushed and painted with red lead primer and two oil-paint coats on the outside and a coal-tar paint coat on the inside. The surface treatment for the light metal consisted of an anodic oxidation followed by a zinc-chrome paint priming and finally a coating similar to that of the steel plates. After 21 months of constant use carrying wet sulfur-containing coal, the light-metal trucks showed no noticeable breakdown or corrosion. The steel trucks showed severe corrosion on the outside and had a 2 mm. thick layer of rust on the inside; their thickness of steel plates was reduced by 1 mm.—RPI.

8.9.5, 3.2.2, 3.6.6

Ship Bottom Corrosion. P. FFIELD. Bethlehem Steel Co. Paper, Soc. Naval Architects and Marine Engrs., New York, Nov. 10, 1950. *Marine Eng. & Shipping Rev.,* **55,** No. 12, 64-67 (1950) Dec; Disc., **56,** No. 2, 62-63 (1951) Feb.

Review of causes and prevention of pitting corrosion of steel ship hulls due to velocity, stray and galvanic currents. Characteristics of galvanic corrosion, galvanic corrosion due to the presence of mill scale and the removal of mill scale are discussed.—INCO. (See Some Aspects of Ship Bottom Corrosion, *Corrosion,* **8,** No. 1 & 2, 29-48, 69-88 (1952) Jan. & Feb.)

8.9.5

Mitigation of Corrosion Within Cargo Compartments Aboard A T-2 Tanker. G. D. HARDEN, Shell Oil Co. Paper, Am. Petroleum Inst., Transportation Div., 30th Ann. Meet., Los Angeles, Nov. 13-16, 1950. *Proc. Am. Petroleum Inst.,* **30,** Sec. V, 115-120 (1950).

A 50 to 80 percent reduction of corrosion rates in the cargo compartments of T-2 tankers used by Shell Oil Co. for shipping petroleum products has been achieved by a combination of galvanic protection for the ballast tanks, using magnesium anodes, and a spraying system for washing the non-ballast tanks with a solution of inexpensive corrosion inhibitor (composition not given). Cost data are given in some detail; savings for a T-2 tanker are estimated at $250,000 to $300,000 depending on the age of the ship. Patents are pending; license agreements at reasonable fees are offered.

8.9.5, 7.6.4

Results of Corrosion of High-Pressure Steam Generators on Ships. (In German.) *Z. Ver. deut. Ing.,* **92,** 560-561 (1950) July 11.

Causes, results and methods of preventing such corrosion.—MR.

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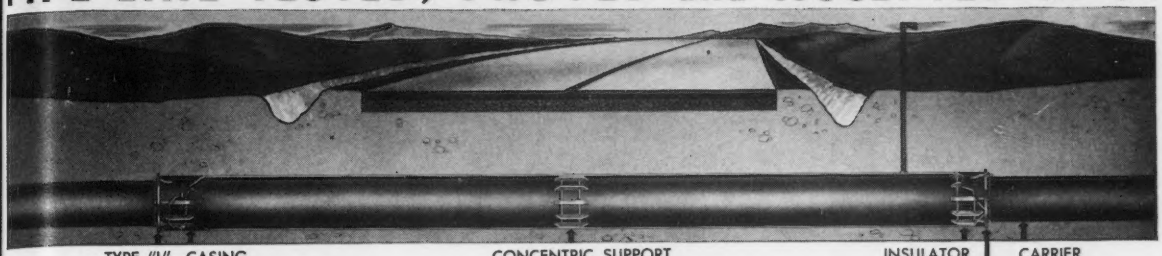

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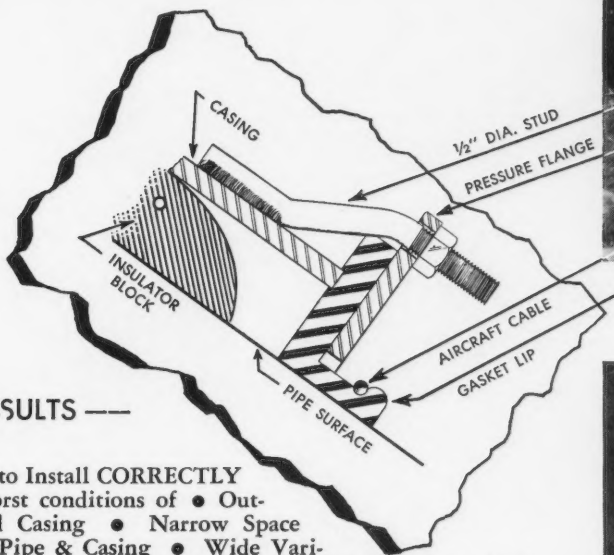
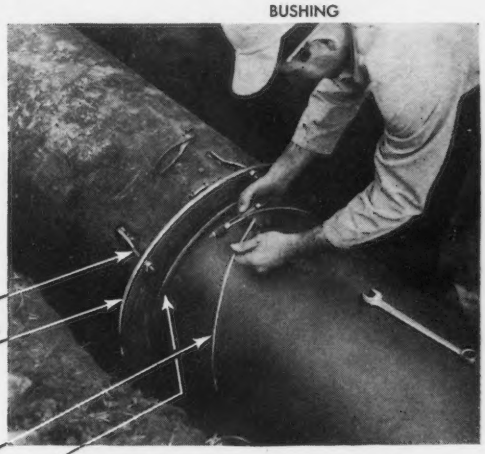
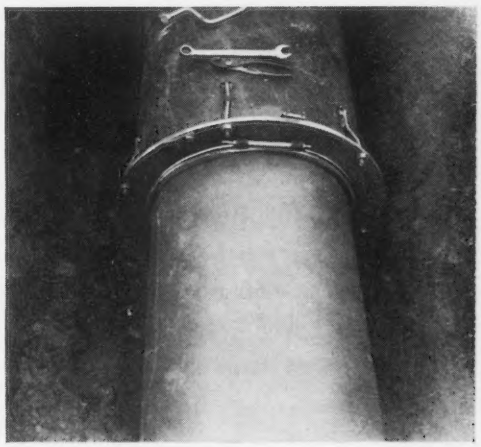




Assembling cable with rubber-covered union for clamping gasket lip to pipe.



THE COMPLETED INSTALLATION
Note that galvanized cable and union are insulated from pressure flange and from pipe.

RESULTS ——

1. Easier to Install CORRECTLY under worst conditions of • Out-Of-Round Casing • Narrow Space Between Pipe & Casing • Wide Variations in Casing Wall and Coating Thickness • Mud • Casing ends beveled — by machine or hand torch.
2. WATER-TIGHT Seal with "L" gasket . . . . . .
   - BUTTED AGAINST CASING as pressure flange is tightened on ½" studs welded to casing.
   - TIGHT TO THE PIPE as aircraft cable (4,600# tensile) is tightened to gasket lip. Union is rubber covered to INSULATE galvanized cable assembly from bare casing structure.
3. Always Insulated from the pipe line when a Concentric-Support Insulator is installed just inside casing after the "drag section" is in place.

AS STRONG & DEPENDABLE AS THE MEN WHO INSTALL THEM

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WRITE FOR BULLETIN 249A

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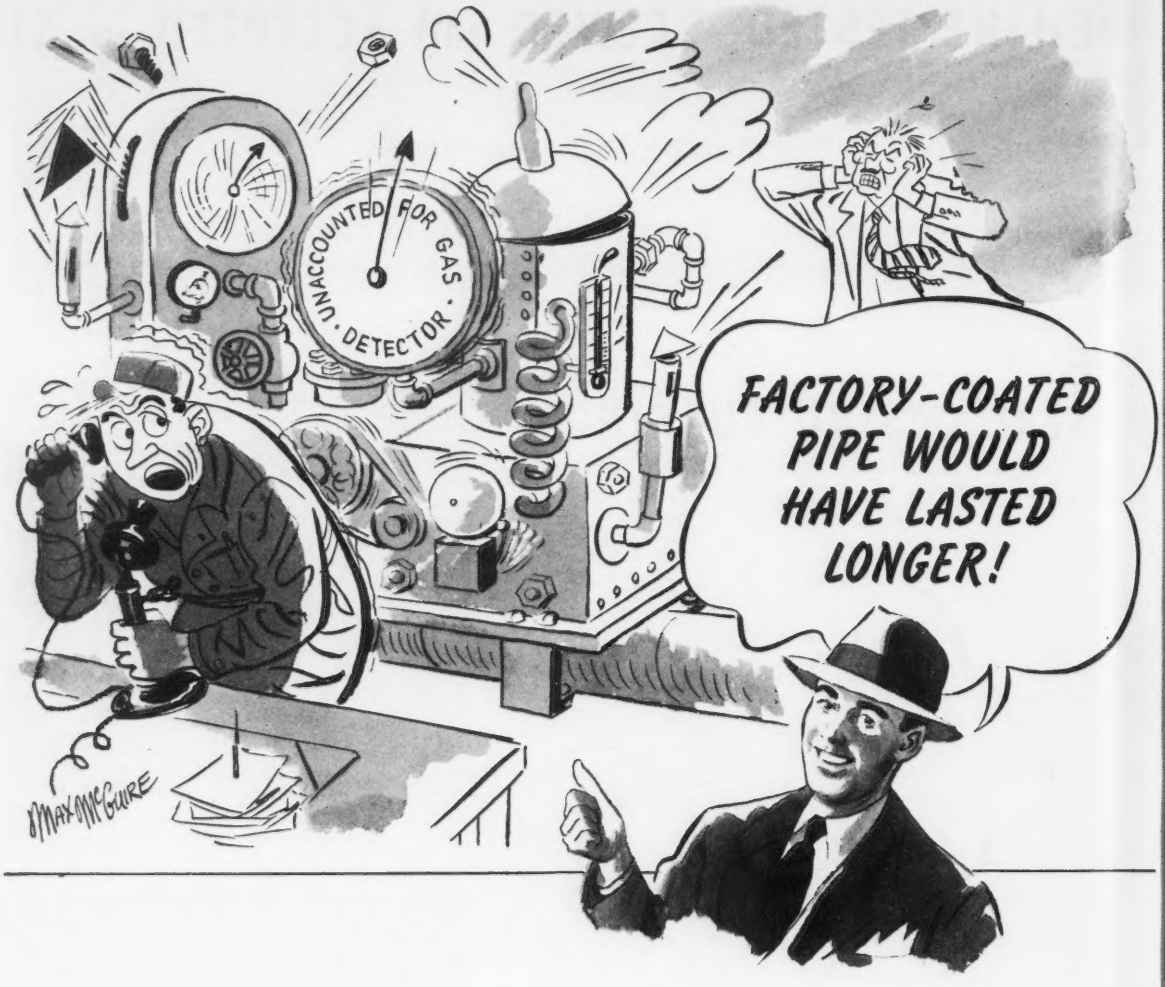
TULSA 9, OKLAHOMA

8,000 Pipe Line Casings installed in 1951 with Williamson Bushings and Insulators.



WHY?

Hill, Hubbell factory-coated pipe lasts longer because all conditions can be precisely controlled at the factory and they can't in the field. With Roto-Grit Blast, we carefully clean every joint of pipe before coating. All coatings and wrappings are precision applied at uniform temperature. Every joint is inspected with electronic holiday detectors before leaving the factory.

Hill, Hubbell and Company

Division of GENERAL PAINT CORPORATION

Headquarters: 3091 Mayfield Road, Cleveland 18, Ohio

Leaders in Pipe Protection for a Quarter Century

PLANTS: Lorain, Ohio ☆ Youngstown Area—at Girard, Ohio
Chicago Area—at Hammond (Gibson), Indiana.
Railroad in transit privileges.

Here's Where PITT CHEM *Quality Control* Pays Off

PITT CHEM quality-control starts paying off from the minute you start coating—and keeps on paying off with every mile you cover. Pitt Chem Hot Applied Enamels not only require less heating time, but they also flow better from kettle to pipe. Their uniform application characteristics and excellent bond helps you to cover *more miles per day* by minimizing coating delays. And, for the same reason, you'll coat *more pipe per ton of enamel.*

These outstanding qualities of Pitt Chem Tar Base Enamels stem directly from our unique position as a basic and integrated producer of pipeline enamels . . . a position that enables us to carefully control each phase of production from coal to finished coating. And remember this: Pitt Chem Pipeline Enamels are manufactured in a plant devoted *exclusively* to coal tar coatings. *We'll gladly provide more product information, technical data or field application assistance on request.*

★ **Standard Grade Tar Base Enamel**
★ **Modified Grade Tar Base Enamel**
★ **Plasticized Grade Tar Base Enamel**
★ **Cold Applied Tar Base Coatings**
★ **Synthetic Base Coatings**

W&D 4118

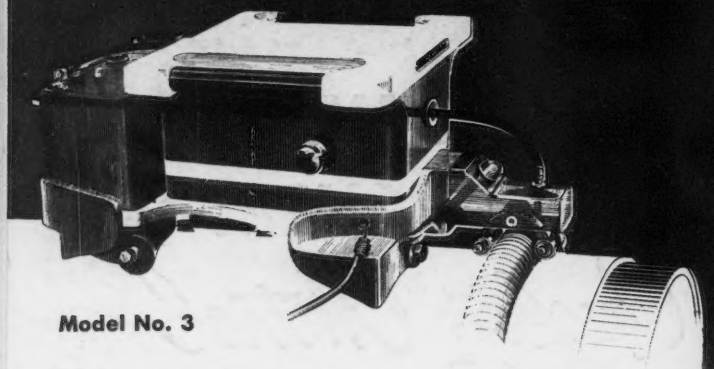
PROTECTIVE COATINGS DIVISION

PITTSBURGH COKE & CHEMICAL CO.

Grant Building • Pittsburgh 19, Pa.

COAL CHEMICALS • AGRICULTURAL CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON • COKE • CEMENT • PIG IRON

The STEARNS ELECTRONIC HOLIDAY DETECTOR



Model No. 3

for making high voltage electrical inspection of pipe line coatings, above ground, as the unit is rolled along on the coated pipe by an operator. The complete Unit consists of the Generator coupled with an Alarm System, the Rolling Coiled Spring Exploring Electrode and Pusher Carriage Assembly. A small 6-volt storage battery serves as the power source.

THOROUGH INSPECTION

Fundamental precepts which are met by the Stearns Detector are:

(1) To generate a high voltage pulse of short duration regulated to hold the crest *intensity* within narrow limits irrespective of pipe size and the variable moisture conditions experienced during field inspection;

(2) To cause such a pulse to re-occur at a *rate* rapidly enough so as to have entirely traversed the coating surface with successive overlapping circumferential bands of ionization as the testing electrode is moved along the coated pipe;

(3) To *apply*, in a simple manner, these testing pulses to the coating by means of an exploring electrode embracing and self-conforming to the variable shape of the exterior of the coated pipe while being held in electrically effective contact with the coating surface at all times; and

(4) To give out audible and visual alarm signals as an instantaneous response actuated by the formation of a spark between electrode and pipe upon encountering a fault in the coating.

Under these principles the Stearns Detector in operation approaches the ideal in testing technique, with maximum safety to the operator, by providing thorough one-pass coverage while uniformly subjecting the coating only to the extent of electrical stress necessary to ensure complete inspection.

LIGHT WEIGHT

The Stearns Detector is fabricated from the lightest ma rials available having the required mechanical and electri strength. The complete unit weighs 28 pounds — is 13 long, 9″ wide, 7.5″ high. A welded magnesium case for t Detector, and a wooden box for two 10-pound 6-volt b teries serve as sturdy containers for storage and shippi The complete shipping weight, including an overnight b tery charger, is 75 pounds.

SIMPLE TO OPERATE

The Stearns Detector can be operated without special tra ing or experience on pipes of all sizes. The proper outp voltage is set before shipment and the regulation is the after automatic — all functions of the Detector being c trolled by a single 'On'-'Off' switch. The patented pulse g erator, which makes possible such automatic voltage regu tion, is an exclusive feature of the Stearns Detector.

DEPENDABLE SERVICE

The Stearns Detector has been developed through ele years of field experience and continued research and become the Standard of the Industry. All major parts the high voltage generating circuit are custom built their specific functions and fitted together i an electrical assembly of proved dependabili Users of Stearns Detectors are constantly sured of receiving equipment in new conditi as a result of the rigid shop and laborat maintenance procedures followed by The D. Stearns Company.

*Patent Numbers Furnished Upon Requ

THOROUGH COATING INSPECTION
ELECTRONIC HOLIDAY DETECTOR
SHREVEPORT, LA. U.S.A. — PATD. & PAT'S. PEND.

The D. E. STEARNS Company

SHREVEPORT, LOUISIANA, U. S. A. CABLE ADDRESS: DESCO

BETTER COATINGS CONSERVE STEE